# NAVY Proposal Submission

The responsibility for the implementation, administration and management of the Navy SBIR program is with the Office of Naval Research (ONR). The Navy SBIR Program Manager is Mr. Vincent D. Schaper. Inquiries of a general nature may be brought to the Navy SBIR Program Manager's attention and should be addressed to:

Office of Naval Research ATTN: Mr. Vincent D. Schaper ONR 362 SBIR 800 North Quincy Street Arlington, VA 22217-5660 (703) 696-8528

The Navy's SBIR program is a mission-oriented program which integrates the needs and requirements of the Navy primarily topics which are critical technologies and have science and technology dual-use potential. A total of 31 Science and Technology (S&T) areas have been identified (see Table 1). Navy topics will be funded from these areas according to a priority it has established to meet its mission goals and responsibilities.

## PROPOSAL SUBMISSION:

There are two ways to submit your SBIR proposal to the Navy. The Navy WILL NOT accept the Red Forms in the rear of this book as valid proposal submission forms of the Appendix A and B. Instead proposers must do <u>one</u> of the following (but <u>not both</u>):

- 1) Generate the Appendix A and B from the Navy SBIR Appendix A and B program, available from the Navy SBIR Bulletin Board (through the Internet) or request a disk copy from the above address (please specify th platform PC, Mac or Unix); print and sign the Appendix A and B form; submit signed form along with one original proposal text and four copies of your entire proposal (Appendix A&B and proposal text) together with a diskette containing the .dat file generated from the Navy SBIR Appendix A and B program to the Navy SBIR Program Office at the above address. (Please note we do not want the entire proposal text on diskette, just the Appendix A and B.)
- 2) Submit the Appendix A and B via the Internet, print and sign the Appendix A and B form; and submit signed form along with one original and four copies of your entire proposal to the Navy SBIR Program Office at the above address. To accomplish this, click on **Business Opportunities** on the ONR Homepage (address -- http://www.onr.navy.mil) and then go to the Navy SBIR On Line Submission Interface, click on that sentence and Appendix A&B will open up. Make sure that you follow instructions to complete the electronic transfer of the appendicies.

#### **Navy SBIR Bulletin Board**

To gain access to the Navy SBIR Bulletin Board, click on **Business Opportunities** on the ONR Homepage (address -- http://www.onr.navy.mil) and then on **Navy SBIR Bulletin Board**. Once on the Bulletin Board go to the **Current Navy SBIR Solicitation** and down load text, forms and compression files on your computer of the **Navy Appendix A** and **B program**, or submit your Appendix A and B via the Internet.

### **About Navy Submissions and This Solicitation**:

This solicitation contains a mix of topics. When preparing your proposal keep in mind that Phase I should address the feasibility of the solution to the topic. Be sure that you clearly identify the topic your proposal is addressing. Phase II is the demonstration of the technology that was found feasible in Phase I. Only those Phase I awardees which have been invited to submit a Phase II proposal by the Navy technical point of contact (TPOC) during or at the end of a successful Phase I effort will be eligible to participate for a Phase II award. If you have been invited to submit a Phase II proposal to the Navy TPOC get a copy of the Phase II instructions from the Navy SBIR Bulletin Board on the

Internet. All Phase I and Phase II proposals should be sent to the Navy SBIR Program Office (at the above address) for proper processing. Phase III efforts should also be reported to the SBIR program office noted above.

The Navy will provide potential awardees the opportunity to reduce the gap between Phases I and II if they provide a \$70,000 maximum feasibility Phase I proposal and a fully costed, well defined (\$30,000 maximum) Phase I Option to the Phase I. The Navy will not award Phase I contracts in excess of \$70,000 (exclusive of the Phase I option). The Phase I Option should be the initiation of the demonstration phase of the SBIR project (i.e. initial part of Phase II). The Navy will also offer a "fast track" into Phase II to those companies that successfully obtain third party cash partnership funds ("fast track" is described in Section 4.5 of this solicitation). When you submit a Phase II proposal it should consist of three elements: 1) a \$600,000 maximum demonstration phase of the SBIR project (i.e. Phase II); 2) a transition or marketing plan (formally called a "commercialization plan") describing how, to whom and at what stage you will market your technology to the government and private sector; 3) a Phase II Option (\$150,000 maximum) which would be a fully costed and well defined section describing a test and evaluation plan for further R&D if the transition plan is evaluated as being successful. While Phase I proposals with the option will adhere to the 25 page limit (section 3.3), Phase II proposals together with the Phase II Option will be limited to 40 pages. The transition plan should be in a separate document.

The Navy will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, the Navy reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

#### TABLE 1, NAVY MISSION CRITICAL SCIENCE AND TECHNOLOGY AREAS

<u>TECHNOLOGY</u> <u>SCIENCE</u>

Aerospace Propulsion and Power
Aerospace Vehicles
Chemical and Biological Defense
Command, Control, and Communications
Computers
Conventional Weapons
Electron Devices
Electronic Warfare
Environmental Quality and Civil Engineering
Human-System Interfaces
Manpower and Personnel
Materials and Structures

Medical Sensors

Surface/Undersurface Vehicles

Software

Training Systems

Computer Sciences
Mathematics
Cognitive and Neural Sciences
Biology and Medicine
Terrestrial Sciences
Atmospheric and Space Science
Ocean Science
Chemistry
Physics
Electronics
Materials
Mechanics
Environmental Science
Manufacturing Science

# **DEPARTMENT OF NAVY 97.1 SBIR TOPIC INDEX**

# MARINE CORPS SYSTEMS COMMAND

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N97-002	COSITE Interference Mitigation Device
N97-003	Lightweight Expeditionary Engineering Materials
N97-004	Development of New Wheel/Tire Concepts for Medium (10T-25T)/Heavy (25T-40T) Ground Combat Vehicles
N97-005	JP8/Diesel Fueled Motorcycle

# NAVAL AIR SYSTEMS COMMAND

NAVAL AIR SYSTEMS COMMAND	
N97-006	Development of a 532 nm Narrowband Optical Filter
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N97-008	Development of Large Area Ultra-High Speed Photo Detectors with Wide Dynamic Range
N97-009	Improved Method of Measuring Ocean Water Characteristics
N97-010	Sensor Fusion Engine
N97-011	Mass Memory Device for Commercial Air Flight Corridors
N97-012	Fiber Optic Microchip Couplers for Ribbon Interconnect Systems
N97-013	Plastic Optics for Low Cost Optical Computer Motherboards
N97-014	Investigation of Optimum Logic and Algorithms for Airborne Use of Instantaneous Frequency Measurement (IFM) Receivers in the Look-through (LT) Mode of Operation
N97-015	Low Cost Silicon Based Color Displays
N97-016	Active Control of Vibration and Shock Loading for Rack Mounted Avionics Components
N97-017	Nondestructive Inspection of Tire Sidewalls
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N97-020	Integration of 3-D Woven Preforms into 2-D Laminates
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N97-029	Gas Turbine High Cycle Fatigue (HCF) Detection, Measurement and Control
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N97-038	Registration of Forward Looking Imagery
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#### DEPARTMENT OF NAVY 97.1 SBIR SOLICITATION TOPICS

#### MARINE CORPS SYSTEMS COMMAND

N97-001 TITLE: Systems and Technologies for Future Amphibious Warfare

OBJECTIVE: To enhance the Marine Corps' future amphibious warfare capabilities the following Warfighting Imperatives need to be addressed; Command and Control, Maneuver, Firepower, Logistics and Training and Education.

DESCRIPTION: The Marine Corps is seeking new, innovative ideas in technologies or systems concepts that support the Marine Corps mission. This is an opportunity to submit ideas, which do not fit specific topics, but may change amphibious warfare and the supporting technology to new paradigms. Proposals should be titled to identify the following specific Warfighting Imperative addressed, as well as identify the content of the proposal:

- 1. Command and Control Innovative technologies in electronics and information management processing to enhance and support Marine Force Command, Control, Communications, Computers and Intelligence to include revolutionary materials for advanced stored energy concepts.
- 2. Maneuver Technologies which include Surface Mobility, Mine Countermeasures, Mine Detection and Survivability
- 3. Firepower Technologies that focus on increasing the lethality and operational effectiveness of combat elements of the Marine Air Ground task force (MAGTF) in weaponry. Innovative targeting sensors that enhance engagement performance of direct and indirect fire weapons.
- 4. Logistics Logistics technologies to enhance and support Operational Maneuver from the Sea (OMFTS) concepts or improve or enhance all phases of logistics from 60 miles at sea up to 40 miles inland with no beach support established. Engineering technologies, bridging technologies, washdown technologies, and combat-load packaging technologies are present FY97 focus areas, though all areas of logistics and combat service support will be considered.
- 5. Training and Education This topic includes all technologies, which enhance and automate training of amphibious forces, such as Modeling and Simulation for visualization, Decision Aids, Data Presentation, Virtual reality, Planning and Rehearsal, Wargaming and other training.

PHASE I: At the end of a six months effort, work should have demonstrated the feasibility of a systems concept or technology, identified critical issues required to transition into the Marine Corps acquisition system, identified goals for systems performance, outlined the current technology maturity, provide evidence that the scientific principles on which the technology is based are sound and justify further work, identify the work necessary in a Phase II effort necessary to demonstrate technical feasibility and increase the potential of the technology or systems concept to transition in Phase III to public and private applications with an exploration of dual use potential.

PHASE II: At the end of a two year effort, the technology or systems concept must have been developed enough to bring subsystems or technologies for transition to maturity, completed sufficient work to enable the technology to transition to an active development program, or become the basis for an operation requirement and acquisition of the technology or subsystem for

Marine Corps applications and or other service applications as well as private sector commercialization. A Phase III Marketing Plan will be submitted with the Phase II proposal.

PHASE III: Phase III must include both public and private sector commercialization with a goal to reduce acquisition cost for Marine Corps through other service/government agency applications, as well as private sector commercialization. The ability to successfully transition in Phase III will be critical both in Phase I selection and Phase II approval.

COMMERCIAL POTENTIAL: All proposals must address the commercial potential required by the criteria in this solicitation.

N97-002 TITLE: COSITE Interference Mitigation Device

OBJECTIVE: Explore innovative approaches to minimize the COSITE interference "AS A SYSTEM SOLUTION" for combat survivable radio communication systems installed in military land combat and amphibious combat vehicles.

DESCRIPTION: Current command and communication control systems on the AAVC7A1 Amphibious Assault Vehicle are targeted to the COSITE interference when two or more radios are transmitting at the same time, causing a receiver degradation for voice and data. COSITE interference can be minimized, if new products can be effectively used in the combat environment. The current command communications systems in the AAVC7A1 consists of eight VHF (30 Mhz-88 Mhz, 50 watts each) SINCGARS radios, one HF (2 Mhz-30 Mhz, 20 watts), one UHF-AM (225 Mhz-400 Mhz, 10 watts), one SATCOM UHF-FM (225 Mhz to 400 Mhz, 18 watts), one PLGR (receiver only, 1565.19 Mhz-1585.65 Mhz) and one UHF PLRS (420 MHZ-450 Mhz, 0.4, 3, 20, and 100 watts) with a total of 13 antennas. Any proposed hardware/software interface must be based on current technology and must "interface" with radios identified above. Proposed hardware/software should meet the following requirements: Able to fit in the AAVC7A1; Ruggedized equipment; User friendly and fault tolerant; Run from unregulated 18-32 Volt DC power with 500 Hz ripple; Minimize antenna quantity; Able to survive land combat vehicle and amphibious vehicle environment

PHASE I: The proposal shall address in detail an optimum solution to minimize the COSITE problem encountered on the AAVC7A1 as "a SYSTEM" and identify potential trade offs that may exist. The proposal shall address in detail a system architecture design for both hardware and software when multiple radios are in operation in the frequencies specified herein. The design shall be tailored to control radio inputs and outputs using alogarithms indicating when and how radios can be transmitting and receiving simultaneously thus minimizing the COSITE problem without changing/affecting the performance characteristics of the radios. The proposals shall be of sufficient detail to allow for government review and selection.

PHASE II: Develop, test and integrate the hardware/software prototype for demonstration and validation in the AAVC7A1.

PHASE III: If successful, it is anticipated that such an approach will have immediate benefits for AAV, other combat vehicle platforms, and other fixed platforms within the Marine Corps as well as other Government agencies. Additionally, techniques developed under this study will have transferability to the commercial area.

COMMERCIAL POTENTIAL: The techniques explored here may have immediate use in commercial application for land and air vehicles.

#### N97-003 TITLE: Lightweight Expeditionary Engineering Materials

OBJECTIVE: Explore technologies for developing lightweight construction materials to be used for mobility, countermobility, and general engineering applications.

DESCRIPTION: There is a requirement to develop materials that are lightweight, high-strength, durable, easily transportable, reusable, easy to assemble, can readily replace existing construction materials, and with reduced storage footprint. Using the previously stated needs incorporate them into the following primary functional areas:

1) Investigate a new design and material that can be used for mobility of vehicles across beaches and soft terrain.

2) develop materials that can be rapidly assembled to create expedient obstacles and barricades.

3) Develop construction materials that are lightweight and can be easily assembled to create bunkers, structures, etc.

PHASE I: Explore technologies for developing lightweight expeditionary construction materials that can be emplaced rapidly by combat engineers as well as develop functional specification. Develop system configuration, evaluate concepts and report on the results. The Phase I proposal must contain the Phase II effort in at least outline form.

PHASE II: Develop a proof of concept prototype, test and demonstrate the prototype, plan Phase III, and report.

PHASE III: Phase III will require military program sponsorship. For successful advance to this phase, a successful proof-of-concept must have been demonstrated, and the USMC sponsor for this SBIR effort will have coordinated transition to demonstration/validation. The contractor must support a successful Phase III transfer by maturing the product to a point for commercial consideration, including manufacturability and cost.

COMMERCIAL POTENTIAL: Lightweight high-strength construction material have wide scale potential throughout industry in the construction of roads, dams, buildings, and various other related tasks.

# N97-004 TITLE: <u>Development of New Wheel/Tire Concepts for Medium (10T-25T)/Heavy (25T-40T)</u> Ground Combat Vehicles

OBJECTIVE: Develop and propose new wheel concepts for the future medium (10T-25T) and heavy (25T-40T) ground combat US Army vehicles. Demonstrate, and validate proposed concepts using available simulation computer programs. Develop necessary subroutines to use NATO Reference Mobility Model (NRMM) program for predicting mobility characteristics for new proposed wheeled concepts for medium and heavy ground combat and support vehicles.

DESCRIPTION: The NATO Reference Mobility Model (NRMM) is an accepted tool for the mobility simulation of ground-combat vehicles in different terrain conditions. However, the program has certain limitations; it is based on experimental test data which is required as an input and it does not accept non-traditional wheel concepts for which no data exist. Therefore, experimental testing is required to generate mobility and soil performance data which is NRMM program to handle new wheel shapes.

PHASE I: New wheel/ tire concepts will be developed based on the present and future technologies in materials, tires, electric drive and control systems for ground combat vehicles. A subroutine shall be developed to accommodate new input data for NRMM simulation for new wheel concepts. Analytical tools will be developed to extrapolate available experimental data, as a first approximation, to predict mobility performance of new wheel/ tire concepts. A plan for small scale model testing of new wheel concepts will be developed to generate data on mobility and soil parameters which will be used in NRMM simulations for evaluating different wheel/ tire concepts. Comparisons will be made, based on NRMM simulations, with similar tracked and conventional wheeled vehicles to select promising concepts for full scale testing in second phase.

PHASE II: (A) Small scale model testing will be done according to the plan developed in Phase I. (B) An extensive experimental full scale testing of promising concepts (based on small scale test data and down selected concepts in Phase 1) will be conducted, preferably at Government facilities, for various combat terrain and obstacle conditions. Experimental data will be analyzed and input will be prepared in the format required for the NRMM simulation program. Detailed simulation studies will be conducted to determine mobility parameters for various combat conditions. The predicted performance comparisons will be made with similar tracked vehicles. Based on the evaluation of these results, down-selection will be made for an optimum wheel concept. (D) The selected concept will be tested in full scale at WES facilities to determine mobility performance.

PHASE III: If warranted, the selected and tested wheel/tire technology may transition to any number of new Marine Corps and Army ground combat vehicles currently under consideration. It is expected that the small business will participate substantially with all final design, fabrication, vehicle integration, and testing of the system.

COMMERCIAL POTENTIAL: The new wheel technology can be used for commercial applications ( heavy transport / earth moving equipment). The NRMM modified code can be used to redesign new-concept wheels for particular commercial applications.

### N97-005 TITLE: <u>JP8/Diesel Fueled Motorcycle</u>

OBJECTIVE: The objective of this topic is to provide a lightweight, powerful, highly mobile motorcycle capable of using JP8 as its primary fuel.

DESCRIPTION: Motorcycles can provided unparalleled mobility in all terrain conditions due to their light weight, high power/weight ratio, and long travel suspension characteristics. The USMC utilizes motorcycles for scout and messenger functions. Current technology off-road motorcycles typically use gasoline powered two or four stroke engines which are not compatible with the future DoD mandated JP8 universal fuel requirement. This problem may be solved by the integration of a small, lightweight, power dense JP-8 fueled diesel engine onto a current state-of-the-art off road motorcycle chassis and drive train.

PHASE I: Identify suitable high performance diesel engines for integration into a commercially available 250 cc equivalent off-road motorcycle chassis. Mobility with the diesel engine installed shall be similar to the standard gasoline fueled model. A conceptual design study shall be performed to analyze engine characteristics, integration

considerations, and performance predictions. A comprehensive final report shall be generated which shall include conceptual layout drawings in contractor format.

PHASE II: Using the Phase I conceptual design study, a detailed design shall be performed and detail fabrication drawings generated. Three diesel powered motorcycles shall be fabricated and evaluated under all terrain conditions.

PHASE III: The motorcycles will be integrated into Army and Marine Corps forces.

COMMERCIAL POTENTIAL: This technology would transition into the commercial transportation industry as motorcycle fuel efficiency, safety, and emissions requirements become more strict.

#### NAVAL AIR SYSTEMS COMMAND

N97-006 TITLE: Development of a 532 nm Narrowband Optical Filter

OBJECTIVE: To develop a narrow linewidth optical filter for use in a laser radar receiver. The linewidth must be less than 0.05 angstroms and have a transmission of greater that 20%. The filter must be able to be designed to operate within the tuning band of doubled Nd:YAG (532 nm). The filter must be able to be used in a imaging receiver system.

DESCRIPTION: Presently the Navy is exploring the use of laser radar for underwater detection of mines near the water surface and shore, where the acoustic techniques are limited. There are a number of programs that are developing systems to perform these tasks. One of the issues with these systems is the solar background, which limits the daytime performance. To achieve equal daytime/nighttime operation a narrow linewidth optical filter is needed to reject all light except within a narrow width centered at the transmitter wavelength. Presently a 2 nm interference filter with 70% transmission is being used as a baseline. If a filter is used with a transmission linewidth ratio greater than the baseline it will reduce the requirements for the laser transmitter or enhance the performance depth. The transmission can be smaller, however the ratio of the transmission per bandwidth must be greater than 16 %/angstrom. The field of view can be reduced or enlarged if the aperture is changed while holding the aperture-field of view product constant (100 degrees-cm).

PHASE I: Provide a report that addresses the design and critical technical issues associated with the production of these new filters and provide recommendations.

PHASE II: Provide a high quality prototype filter with a maximum bandwidth of 0.05 angstrom, field of view of 15 degrees full angle, clear aperture of 6.5 cm and at least a 20% transmission.

PHASE III: Transition technology into existing Navy programs.

COMMERCIAL POTENTIAL: Any filtering device developed can be used in any system hampered by the solar background, for example, remote sensing of chemical pollutants and astrological observing.

N97-007 TITLE: High Speed Optical Modulator for High Capacity Systems

OBJECTIVE: Develop a compact optical modulator to operate in the mm-wave range (40-80 GHz), and capable of handling high optical power (> 200mW) for communication system distribution.

DESCRIPTION: High performance communication links are required for high capacity distribution systems (like cable TV distribution). An integrated optical modulator can provide reasonable modulation speed, but they only operate at low optical powers, and are not suitable for distribution networks. For communication purposes, it is imperative to find an inexpensive source operating at high optical power and at high modulation frequencies in order to link the distribution center to the customer houses. With a high power modulator, services like cable TV, high speed network access, etc., integrated in only one link could be offered.

PHASE I: Provide a feasibility study for a compact, high speed, high optical power modulator. The device must operate at mm-wave frequencies, with optical power above 200mW (CW).

PHASE II: Develop, test, and operationally demonstrate the proposed modulator.

PHASE III: Produce a compact, high speed, high optical power modulator suitable for high capacity distribution systems and for high performance on-board links.

COMMERCIAL POTENTIAL: This modulator would be of great benefit to commercial industries involved in optical communications and phased array antennas development.

N97-008 TITLE: <u>Development of Large Area Ultra-High Speed Photo Detectors with Wide Dynamic Range</u>

OBJECTIVE: Develop a large area (diameter >2mm active area) photo-detector with ultra-high speed (>10Ghz) and very high dynamic range (>6 orders of magnitude).

DESCRIPTION: Ultra-high speed photo-detectors are used in a variety of technology fields, from communications to oceanographic LIDARs. Current ultra-high speed photo-detectors have very small active area (<.1mm diameter). In the field of communications the very small active area makes system alignment extremely difficult and time consuming. In a LIDAR system the small active area severely reduces the available field of view of the system. Currently, the two parameters of ultra-high speed and large active area are mutually exclusive. A photo-detector that combines both parameters is needed.

PHASE I: Provide a feasibility study for a new type of photo-detector. The photo-detector must combine ultra-high speed (>4Ghz) with large active area (diameter >2mm).

PHASE II: Develop, test, and operationally demonstrate the photo-detector developed under Phase I.

PHASE III: Produce an ultra-high speed large area photo-detector that can be used in a variety of technology fields such as modulated pulsed LIDARs.

COMMERCIAL POTENTIAL: This new photo-detector would be of great benefit to commercial industries involved in optical communications.

#### N97-009TITLE: Improved Method of Measuring Ocean Water Characteristics

OBJECTIVE: Develop a more compact, more reliable technique for measuring the optical characteristics of ocean water such as reflection and total attenuation.

DESCRIPTION: Measurement of the optical properties of the ocean is critical to ocean water LIDAR programs. Currently, the Navy uses an optical transmissometer to measure the attenuation of the water at various depths and for various optical wavelengths. This is achieved by immersing a light source and detector into the water and measuring the electrical signals at the surface. There are several drawbacks of using this approach. First, submersion of the light source and detector tend to cause high power to be sent over long lengths of expensive and unreliable underwater armored cable. Further, an expensive underwater housing is required to protect the instrumentation. This results in the need of a large support winch and a compatible ocean vessel. Second the measurement of attenuation at different optical wavelengths is difficult. Most systems must be brought to the surface and manually changed to set the optical wavelength. A simpler, lighter, more reliable method of measuring these properties would allow them to be done on inexpensive platforms without the expense of specialized equipment.

PHASE I: Provide a feasibility study for a new type of measurement system for ocean water optical properties. The method must be able to measure the total attenuation and scattering of the water as a function of wavelength and depth. The method must able to measure depth and temperature simultaneously with the scattering and attenuation. Additionally, the method should be lighter, more compact and more modular than the current technology.

PHASE II: Develop, test and operationally demonstrate the measurement system developed under Phase I.

PHASE III: Produce the ocean water optical properties measurement system demonstrated in Phase II for use in determining the water quality for all active and passive ocean-based optical remote sensing programs.

COMMERCIAL POTENTIAL: This new technique would benefit commercial industries involved in bathymetry, fish-finding, and environmental cleanup.

# N97-010 TITLE: Sensor Fusion Engine

OBJECTIVE: Explore hardware and software alternatives for the efficient, rapid, and accurate integration of current and planned electronic sensors.

DESCRIPTION: The emerging threat to Naval assets in the littoral zone is becoming increasingly critical with the deployment of inexpensive but very capable anti-ship cruise missiles employing low altitude flight profiles and advanced low Radar Cross Section (RCS) technology.

Investigate efficient methods of sensor fusion and integration that combine onboard and off-board sensor assets with real-time and non-real time information in an optimal fashion. Each sensor has specific advantages and disadvantages depending on the target size, aspect and range, the environment, and mission requirements.

PHASE I: Initial efforts should investigate the Human Machine Interface (HMI) efforts needed to gain situational awareness with sensor fusion of real time and non-real time sensor inputs for aircraft combat systems. Alternative design approaches shall be developed with the advantages and disadvantages of each approach documented. Select the optimum HMI design approach while taking into account the present UNIX/MOTIF based HMI being used in present systems. Review present computer hardware and software elements to determine the tradeoffs between cost and capability for the implementation of the selected approach. The Phase I effort shall be complete with the preliminary HMI design and hardware and software requirements for HMI display of sensor fusion data

PHASE II: Continue with the results of Phase I. Refine and finalize the preliminary design. Select and procure software and hardware elements. Fabricate and demonstrate a working prototype sufficient to demonstrate proof of principle.

PHASE III: Utilize the results of Phase II to determine the optimum method of incorporating and integrating the designed system into the E-2C weapon system for use in the E-2C fleet defense mission requirements.

COMMERCIAL POTENTIAL: Innovative approaches and solutions will have immediate applicability to complex manufacturing systems and processes. Modern refineries and power generation stations use multiple sensors to support a high level of system automation for streamlined operations and reduction of staff. New and advantageous methods of sensor fusion for improved operations and efficiencies are desirable and required in several industries.

## N97-011 TITLE: Mass Memory Device for Commercial Air Flight Corridors

OBJECTIVE: Develop a method for storing, retrieving and displaying international commercial aircraft flight corridor data to allow for the improved target identification of unknown air targets that are potential threats to Naval assets.

DESCRIPTION: Tactical aircraft equipped with very capable sensor and communications systems, can detect, identify and track air targets for battle space management. Unknown air targets having flight paths presenting potential threats to Naval forces are engaged to the degree specified by the operative Rules of Engagement. The utilization of sensor assets in the prosecution of potential targets ties up operational aircraft and places commercial aircraft in a potentially hazardous situation. The graphical presentation of commercial flight corridors will allow aircrews to determine if unknown air target flight paths correlate with known flight corridors.

PHASE I: Investigate the several technologies available for mass storage of commercial flight corridor data. Generate design alternatives for the integration of selected technologies. Integration must be completely transparent to existing systems and must not impact any current operations. Investigate trade-offs of capability versus cost. Select the preferred alternative and develop preliminary design and integration strategy for fabrication in Phase II.

PHASE II: Refine preliminary design and fabricate mass memory system and required interfaces. Demonstrate ability to correlate unknown air targets with known commercial flight corridors in a lab environment.

PHASE III: Utilize the results of Phase II to determine the optimum method of incorporating and integrating the designed system into the E-2C weapon system for use in accordance with E-2C mission objectives while reducing potential threats to civilian aircraft.

COMMERCIAL POTENTIAL: This system will have potential utility with any agency or organization concerned with controlled airspace. Border enforcement and drug interdiction organizations will be able to utilize this technology.

# N97-012 TITLE: Fiber Optic Microchip Couplers for Ribbon Interconnect Systems

OBJECTIVE: The objective of this program is to develop a family of microchip star and tree optical waveguide couplers suitably packaged to interface ribbon cable interconnect systems.

DESCRIPTION: Advanced ribbon fiber optic cable systems are being developed for military and commercial aircraft as well as for commercial telecommunications and computer interconnects. Current couplers used for distributing optical signals between a large number of users or terminals are bulk devices which are relatively large in size and high in cost. A new family of microchip couplers is being explored based on thermally grown silica or ion diffused

waveguides which can be fabricated on a microchip and should be capable of meeting the environmental extremes of military users while being very low in cost to meet the requirements for commercial telecommunications and Cable TV.

This program will develop a family of low cost microchip couplers which are compatible with silicon V-Groove connectors and splices currently being developed for fiber optic ribbon cables.

PHASE I: The contractor shall analyze and design a family of microchip star and tree optical waveguide couplers which are compatible with ribbon cable interconnect systems. The analysis shall include a material loss analyses for the .63 micrometer, .85 micrometer, .98 micrometer, 1.06 micrometer, 1.3 micrometer and 1.5 micrometer optical wavelengths. The analysis shall also include stable operation over typical aircraft operating temperature, vibration, shock, etc. The coupler and package design shall be compatible with silicon V-Groove micro-machined and molded multichannel connectors and splices being developed for fiber optic ribbon cables and the package design shall provide suitable environmental protection for the microchip. Both lensed and physical contact designs for the interface shall be considered.

PHASE II: The contractor shall apply the results of the Phase I effort to develop, fabricate and test a family of microchip star and tree optical waveguide couplers suitably packaged to interface ribbon cable interconnect systems and operate over military aircraft environmental extremes. Based on the Phase I design, the contractor shall fabricate and package five 1x2, 1x3, 1x4 tree couplers and five 2x2, 4x4 and 8x8 star couplers. Environmental testing and optical measurements will also be made over conditions typical of those experienced in military or commercial aircraft.

PHASE III: This technology will have transition potential to the DARPA Optical Micronet program, the Joint Strike Fighter (JSF) Program and the DARPA/NAVAIR Vehicle Management System Integration Technologies for Affordable Life Cycle Cost (VITAL) Program which will be concentrating on the use of commercial off-the-shelf hardware for fighter, rotary wing and transport aircraft.

COMMERCIAL POTENTIAL: Low cost, rugged couplers can be utilized for commercial telecommunications and Cable TV systems, industrial control applications, local area networks for office buildings and hospitals, and automotive applications.

#### REFERENCES:

- 1. IEEE STD 1596 for the Scaleable Coherent Interface (SCI)
- 2. Unisys Corporation, "Navy Optical Backplane Interconnect System (OBIS) Contract Phase I Trade Study Report" dated October 1993.

# N97-013 TITLE: Plastic Optics for Low Cost Optical Computer Motherboards

OBJECTIVE: The objective of this program is to investigate the application of plastic optical fibers, molded plastic optical lenses and novel molding techniques and materials to develop low cost computer motherboards or backplanes.

DESCRIPTION: Military and commercial computers currently utilize multi-layer printed circuit motherboards to interconnect computer cards or modules. These printed circuit boards consist of fiberglass laminates on which metallic interconnects have been lithographically defined. Via holes are used to provide the interconnect between layers of the laminate and high density connectors are attached to the board to allow electrical contact between the circuit board and computer cards or modules which contain the integrated circuit chips and multi-chip modules.

The use of optical waveguides can provide a high performance alternative to electrical circuit boards. Recent dramatic improvements have been made in plastic optical fibers which have reduced the losses, and increased the bandwidth and operating temperature range. Advances in molding techniques and plastic materials have produced lens arrays with very low cost and good optical performance which can be used for connectors with easy alignment. Advanced materials such as polycarbonate permit highly stable operation over environmental extremes. This program will investigate the use of plastic optical fibers, connectors, lenses, and thermoplastic and/or thermosetting materials and advanced molding and forming techniques to demonstrate low cost rugged computer boards to optically interconnect computer cards or modules. These monolithic plastic motherboards should exhibit high bandwidth and environmental stability, with ease of module insertion. Provision should also be made for power and ground distribution external or internal to the motherboard.

PHASE I: The contractor shall first perform a cost/performance analysis of plastic optical fiber and connector materials, molding and fabrication techniques; thermoplastic, thermosetting or alternate low cost materials and related

mechanical and optical components required to mass produce low cost passive optical computer motherboards. This analysis shall include an optical power budget for motherboard transmission, methods of optical power splitting and/or combining within the backplane, and suitable backplane to module connector concepts. Both two and three dimensional concepts shall be explored.

PHASE II: The contractor shall apply the results of the Phase I effort to develop, fabricate and test optical motherboards to interconnect computer cards or modules. The contractor shall demonstrate both parallel and serial optical signal distribution within the module, and measure signal loss at all interfaces. Testing and measurements will also be made over environmental conditions typical of those experienced in military avionics enclosures.

PHASE III: This technology will have transition potential to the DARPA Optical Micronet program, the Joint Strike Fighter (JSF) Program and the DARPA/NAVAIR Vehicle Management System Integration Technologies for Affordable Life Cycle Cost (VITAL) Program which will be concentrating on the use of commercial off-the-shelf hardware for fixed wing and rotary wing military and commercial aircraft control systems.

COMMERCIAL POTENTIAL: Low cost optical motherboards can be utilized for high performance workstations and personal computers which incorporate the Scaleable Coherent Interface (SCI) or alternative high speed backplane protocols.

#### REFERENCES:

- 1. IEEE STD 1596 for the Scaleable Coherent Interface (SCI)
- 2. Unisys Corporation, "Navy Optical Backplane Interconnect System (OBIS) Contract Phase I Trade Study Report" dated October 1993.

N97-014 TITLE: <u>Investigation of Optimum Logic and Algorithms for Airborne Use of Instantaneous</u>
Frequency Measurement (IFM) Receivers in the Look-through (LT) Mode of Operation

OBJECTIVE: Develop optimum logic and algorithms for airborne use of Instantaneous Frequency Measurement (IFM) receivers in the look-through (LT) mode of operation.

DESCRIPTION: The benefits of IFM receivers to intercept radar signals are well known: large dynamic range, high probability of intercept on single pulse, wide band width, etc. However, airborne use of IFMs has been limited, chiefly because IFMs have high sensitivity to own-ship interference caused by onboard radars, communications/navigation equipment and jammers. The known solution to the IFM interference problem is to have the receiver operate for short periods of time (less than 5%) while the interfering onboard transmitters are silenced. This mode of operation is known as LT and has not been successfully implemented nor documented for IFM airborne applications.

PHASE I: The proposed SBIR would develop the optimum LT algorithms, logic and processing speeds for using IFM receivers in airborne applications. The methodology would be to utilize an existing off-the-shelf IFM and laboratory generated tactical radar schemes that will establish the optimum manner in which to sample the radar environment with an IFM receiver. The probability of intercepting each generic type of radar emitter would be analyzed and tested in the laboratory.

PHASE II: Develop, test and demonstrate the derived IFM LT mode against actual emitters in an operational scenario on an electronic warfare (EW) Test Range.

PHASE III: Transition IFM LT technology/methodology into viable full scale development candidate for follow-on and upgrade of radar warning receiver (RWR), electronic support mission (ESM), tactical jamming (TJS) and electronic intelligence (ELINT) systems.

COMMERCIAL POTENTIAL: Radar signal processing improvement for FAA air control situations, FCC frequency deconfliction/surveillance and for Test Range frequency monitoring.

## N97-015 TITLE: Low Cost Silicon Based Color Displays

OBJECTIVE: Increase the functionality and productivity of the human operator while decreasing the life cycle cost of associated display system, whether helmet mounted, in flat panel mosaic arrays, projection displays or conformal mounted.

DESCRIPTION: The Navy currently is investigating the use of color helmet mounted and flat panel multifunction displays for aircraft operations. To date much of this work has been based on either miniature cathode ray tubes or on use of liquid crystal display technology both of which have some drawbacks in terms of either cost or performance in tactical aircraft applications. Development work is also progressing in plasma display technology and field emission displays technology operating at high voltages. As a vital link between the operator and aircraft avionics or flight control systems, displays which offer both high brightness and high definition potential are required, especially with increasing demands for increased situational awareness, joint operations and crew workload reduction. Affordability of the display system and it's ability to operate in the military environment are also key requirements. An approach which offers the potential to meet these needs is the use of silicon based displays which are fabricated using the same processes as are used for high volume semiconductor parts such as memory chips. Applications would ultimately include virtual displays for training systems, rehearsal systems, maintenance systems, hand held displays, and tactical aircraft helmets. Extendability to cockpit mounted flat panel displays, cockpit/simulator mounted conformal arrays, and situational displays (CRT replacements) based on arraying/projection are also of interest.

PHASE I: Provide a feasibility study which analyzes the ability of low cost highly repeatable silicon process technology to yield high-brightness/high-definition/low voltage and light efficient color displays for possible applications to naval airborne weapons systems and ground based support systems. If feasible, sample display items would be useful in conjunction with this analysis. Identify array size, array dimensions, pixel pitch, gap width, fill factor, frame update time, throughput, contrast ratio, rise/fall times, power conditions, power dissipation, projected battery life (if battery powered) and other important display parameters. Industry projections concerning the producibility, availability, affordability and extendability of the display media and associated electronics shall be included. Particular attention should be given to the at sea operational environment and tactical aircraft operations. If necessary, applications should distinguish between land and sea based operations. Applicability of the technology beyond display systems is also of interest.

PHASE II: Develop, test and operationally demonstrate a preliminary color tactical display system (which provides full color at each pixel) based on the technology identified during Phase I. Determine operational performance and projected cost for developmental and eventual production applications. Study and project any special maintenance, safety, or operational requirements for such systems.

PHASE III: Produce a helmet mounted full color low cost subsystem based on the technology demonstrated in the Phase II effort. This will include transition to other Navy programs such as training, mission planning, rehearsal, maintenance, operational systems, etc.

COMMERCIAL POTENTIAL: Low cost, high brightness, high definition, and high reliability flat panel color displays for helmet mounting or mosaic large area arrays would have a substantial commercial market including video games, commercial airlines, industrial use, medical and others.

REFERENCES: Commercial Standards Regarding Radiated Energy and Operator Safety

#### N97-016 TITLE: Active Control of Vibration and Shock Loading for Rack Mounted Avionics Components

OBJECTIVE: Reduce the "g" loading that rack-mounted avionics components experience as a result of vibrations and shock impact forces.

DESCRIPTION: The DOD makes extensive use of rack mounted avionics systems in many of its tactical aircraft. These racks are typically either hard mounted to the airframe or mounted on rubber vibration isolator (passive) mounts. The passive mounts provide some vibration reduction, but minimal shock impact reduction. With the DOD emphasis on commercial-off-the-shelf (COTS) equipment, a more benign vibration and shock environment must be fostered within these tactical aircraft. Given this environment, both new COTS avionics components and the current

components should see improved reliability (i.e., higher MTBF). In order to reach this state though, an active system that is able to reduce both vibration levels and shock impact loading must be developed.

PHASE I: Develop and test a single actuator active system that is able to dampen both vibration levels and shock impact forces. Demonstrate how the prototype system can significantly reduce vibration levels in the 10 to 300 Hz range, while also reducing the "g" loading due to shock impact by at least 75 percent.

PHASE II: Take the prototype unit developed under Phase I and expand it to isolate a rack mounted avionics system from a tactical aircraft. Test and operationally demonstrate the effectiveness of this system through a series of ground and flight tests.

PHASE III: Show that the technology produced during Phase II can be effectively mass produced and incorporated efficiently into tactical aircraft.

COMMERCIAL POTENTIAL: New vibration/shock isolation system for rack mounted components may be used on many of the current commercial aircraft. The technology is applicable to the automotive and related manufacturing industries for components requiring extreme precision.

#### N97-017 TITLE: Nondestructive Inspection of Tire Sidewalls

OBJECTIVE: The development of a reliable means for inspecting tire sidewalls, specifically for breakage of cord plies and separations of cords.

DESCRIPTION: Aircraft tires are typically retreaded several times during their lifetimes. Currently, inspection of the tread area is performed, after completion of the process, using holography. The sidewall area is not inspected, as a consequence there is a higher percentage of tire sidewall failures in retreaded items than in non-retreaded items.

The use of retreaded tires of aircraft is of great economic advantage to the Navy however the inspection of all areas of the tire is necessary to get the greatest use from these items while maintaining safe operating conditions.

PHASE I: The contractor is expected to demonstrate feasibility for (nondestructively) inspecting tire sidewalls for cord ply breakage, separation of cords and other defects that would limit the usefulness of the tire. The inspection method will, ideally, be suitable for the tread area of the tire as well.

PHASE II: Inspection equipment and inspection technique should be production ready. This equipment will be used, primarily, at the tire retreading site. However, portability or the ability to use the equipment at alternate locations would be an advantage.

PHASE III: The contractor should be able to deliver the inspection equipment to tire manufacturers and train inspection personnel in the use of the technique.

COMMERCIAL POTENTIAL: The inspection of retreaded tire sidewalls will be applicable to commercial aircraft and trucks as well as improving the safety of retreaded tires purchased by the private sector.

## N97-018 TITLE: Woven Hybrid Inserts for Lightweight Affordable Aircraft Structures.

OBJECTIVE: Develop three-dimensional solid and hollow inserts (woven preforms), fabricated of hybrid composite materials (carbon and glass fibers) for joining aircraft structural components, such as wing skins and spars.

DESCRIPTION: The benefits of weight, cost, and supportability savings for high performance air vehicles can be realized if the structural components are designed and fabricated with improved structural integrity and reduced part count. This can be accomplished by designing composite structural joints without utilizing fasteners, but by applying innovative cocured joining techniques. Exploratory work in recent years performed by domestic and foreign companies, has demonstrated the feasibility of increased load carrying capability of composite test specimens having joints, designed and fabricated with woven inserts (preforms). But mismatch in stiffnesses and coefficients of thermal expansion in the joints produce microcracks which limit their applications, specifically in primary structural joints. Therefore, it is expected that the utilization of solid three-dimensional hybrid inserts (woven preforms fabricated of carbon and glass fibers) with proper design configurations and fiber orientations could reduce or eliminate the undesirable stress concentrations, and microcracks generated by residual thermal stresses. It is envisioned that the

application of hollow three-dimensional hybrid inserts could further reduce the undesirable stress concentrations and residual thermal stresses, resulting in superior structural joints with improved load carrying capability. The hollow three-dimensional woven inserts with appropriate design, shape, and size also have potential applications for naval surface weapons launcher systems.

PHASE I: Develop three-dimensional solid and hollow inserts (woven preforms) fabricated of hybrid composite materials (carbon and glass fibers) and fabricate specimens containing structural joints. Perform preliminary tests and analyses to determine joint strength, elastic properties of the inserts, and residual thermal stresses. A Preliminary photomicrographic examination shall also be performed to detect the presence of microcracks.

PHASE II: Improve the weaving pattern and fabrication techniques, perform detailed analyses and conduct comprehensive tests to determine joint strength, elastic properties, residual stresses and damage tolerance. Demonstrate applicability of the innovative joints through sub-scale and full-scale component testing. Develop appropriate repair methods for supportability.

PHASE III: Fabricate representative structural joints and qualify through ground and flight tests. Flight ready the hardware for incorporation into an aircraft program.

COMMERCIAL POTENTIAL: Development of the proposed structural joints has various applications in the transportation industry, specifically in highly loaded critical structural joints which result in improved reliability and safety.

# N97-019 TITLE: Advanced Nondestructive Evaluation System for Corrosion Detection.

OBJECTIVE: To develop a compact and portable corrosion detection system that would allow the inspector to quickly detect and quantify the amount of corrosion present in an aircraft structural component.

DESCRIPTION: Corrosion, if left uncontrolled, can lead to catastrophic failures by undermining the functional material properties of the weapon systems. The costs related to corrosion damage are astronomical. As a result an advanced portable NDE techniques capable of finding hidden corrosion, well before it can jeopardize the weapon systems, is critically needed. Corrosion under paint, between lap joints, under aircraft skins, under fasteners heads and in other hidden parts are some examples were corrosion needs to be detected.

PHASE I: In Phase I of the proposed effort the contractor will build a laboratory model that will demonstrate the feasibility of the device for detecting hidden corrosion. The contractor will determine the ultimate sensitivity of the technique on a simulated aircraft structure with varying amounts of corrosion.

PHASE II: In Phase II of the proposed effort the contractor will develop a complete NDE system for the detection of hidden corrosion. The system should be rugged, reliable, portable, and easy to interpret. I is advised at this point that the contractor team up with a larger company who might be interested in transitioning the new technology.

PHASE III: Full manufacturing of the new NDE technique.

COMMERCIAL POTENTIAL: It is anticipated that a system of this nature will have significant benefits in the commercial aerospace industry as well as in the maritime and automotive.

# N97-020 TITLE: Integration of 3-D Woven Preforms into 2-D Laminates

OBJECTIVE: Investigate, develop and optimize manufacturing methodologies to combine 3-D woven preforms and 2-D laminates to fabricate efficient structural parts for aircraft applications.

DESCRIPTION: Numerous programs are underway investigating the use of 3-D woven and braided composite structure for aircraft applications in order to increase out-of-plane strength of traditional laminated structure. Some of these programs use dry fiber followed by RTM to fabricate the composite part, while others start with prepreg material in the weaving process. However, the overall use of 3-D configurations in a structural part is typically not cost or weight efficient for the majority of aircraft applications. The most desirable configuration is an integral combination of a 3-D preform into a 2-D laminate. To date, integration of 2-D and 3-D structures has only been addressed as a secondary issue with lap bond or cocure attachment methods investigated. The integration of these two material forms

and technologies is needed to provide an efficient, quality aircraft part able to sustain the various loading configurations. This effort is to address this integration effort through the development of novel and structurally efficient design concepts.

PHASE I: Develop and evaluate design concepts to integrate 3-D material forms into a 2-D laminate. Perform structural trade studies to determine and predict cost and weight efficiencies of selected concept(s). Develop preliminary test verification procedure and perform small specimen testing to provide confidence in selected concept to proceed to Phase II.

PHASE II: Concept refinement and processing optimization through analytical and experimental investigations. Generation of a data base for preliminary design incorporating various loading and environmental conditions. Verification of the developed technique through sub-scale and full scale component testing.

PHASE III: Fabricate and qualify through ground and flight test, flight ready structural hardware for incorporation into an aircraft program.

COMMERCIAL POTENTIAL: The design and fabrication methods developed have application throughout the commercial aircraft industry as well as the automotive and truck industry.

#### N97-021 TITLE: Low Cost/Light Weight Composite Structural Components

OBJECTIVE: To reduce acquisition and maintenance costs of doors and panels throughout the aircraft by the use of pultruded stiffening concepts to provide a durable, low weight, corrosion resistant structure with a repeatable manufacturing process.

DESCRIPTION: Numerous applications are found throughout the aircraft which incorporate stiffened composite panels. These panels consist of a minimum curvature laminate which is restrained from buckling through the use of cocured stiffeners. Examples of this type of construction can be found in cargo floors, fuselage side panels and landing gear doors. An alternate design to this labor intensive hand lay-up process is the use of pultruded fiberglass or graphite stiffeners, which could be fabricated at a minimum cost, to replace the hand-laid-up stiffeners and achieve the same level of performance. For some applications, it may be possible to design multiple sections that would have the same configuration and thus would lend more easily to large production runs and interchangeability. Sections would be fabricated in one piece minimizing costs and would be such that they would interlock minimizing time consuming mechanical installations.

PHASE I: Perform feasibility and conceptual design study to identify potential designs. Define cost and weight savings. Fabricate coupon specimens to substantiate design properties.

PHASE II: Perform detail design for application in a selected baseline aircraft. Fabricate and test element and full scale components to confirm design projections.

PHASE III: Perform qualification testing including strength, durability and damage tolerance testing. Fabricate & install full size parts in flight aircraft. Evaluate performance testing.

COMMERCIAL POTENTIAL: The structural concepts could be applied to most flat and slightly curved parts in all commercial aircraft. Other vehicles such as trucks and rail cars with stiffened panels could also benefit from the technology developed.

# N97-022 TITLE: Lightweight Non-Corroding Coupling Mechanisms

OBJECTIVE: To develop lightweight, non-corroding universal joints and coupling mechanisms for rotorcraft drive shafts.

DESCRIPTION: All rotorcraft/helicopters require drive shafts to transfer power from the engines to various rotors. These drive trains all make extensive use of couplings and universal joints to transfer the engine torque while accommodating the vehicle engine/rotor configuration. These joints and couplings add considerable weight to the drive train and require careful maintenance in corrosive environments. A need has been identified for lightweight, non-

corroding universal joints and coupling mechanisms for application in rotorcraft drive systems which can operate in the Navy environment.

PHASE I: Identify preliminary design concepts for composite coupling mechanisms for transfer of torque and accommodation of shaft misalignments.

PHASE II: Develop, fabricate and test promising concepts identified during Phase I.

PHASE III: Transfer Phase II design into Navy weapons system.

COMMERCIAL POTENTIAL: Durable, lightweight coupling mechanisms have potential in both commercial and military rotorcraft systems, and are attractive for use in other industrial and automotive drive shaft applications.

#### N97-023 TITLE: Reduction of Noise and Vibration Stresses on Tactical Aircraft Flight Crews

OBJECTIVE: Develop a reliable, low cost, system to attenuate the high level of ambient energies, noise and vibrations, perceived by persons in a variety of environments, most specifically in the cockpits of tactical aircraft. The system shall reduce the deleterious effects on job/mission performance, caused by the physiological and psychological effects of exposure to stress producing levels of noise, and prevent short and long term hearing loss.

DESCRIPTION: The system developed will provide a means of significantly reducing the perceived level of stress producing noise within the crew compartment areas and shall enhance the reliable perception and understanding of the desired audio information and warnings associated with installed airframe and avionics systems. The noise reduction system shall have negligible impact on the weight and balance of the aircraft, preferably be worn as personal equipment without unduly encumbering the user, and shall be compatible and interoperable with the aircraft and, as well as, other operational environments.

PHASE I: Conduct a system engineering and analysis effort to define the design of a cost effective approach to attenuating the high noise and vibrations perceived by personnel operating military aircraft and exposed to other stressful environments (e.g., shipboard engineering spaces, flight deck and flight deck and flight line areas, mechanized infantry, etc...) and in commercial applications, such as manufacturing, agriculture and construction. Estimate the cost and schedules and technical risks associated with developing and implementing the approach. Assess the positive and negative impacts of the system on overall job/mission performance.

PHASE II: Develop working prototype system(s) to allow optimization of system design. Evaluate effectiveness in the laboratory and in the actual environments, at least in and around tactical aircraft. Analyze the performance and assess the production and installation costs and deliver a technical report and production data package for follow-on procurement, actual Plan and participate in applicable laboratory and field tests.

PHASE III Refine the design of and implement the system. Adapt the system for use by all potential armed force users, tailoring it as necessary to meet the mission-specific requirements. Transition to commercial users.

COMMERCIAL POTENTIAL: The system would be useful to operators of heavy equipment and other persons working in close proximity to noise producing machinery. The ultimate goal is to eliminate or greatly reduce high level ambient noise while still facilitating the perception and understanding of audio information.

REFERENCES: Joint Mission Requirement M051-04-94, dtd 04/11/94, "Enhanced Hearing Protection for High Noise Environments."

#### N97-024 TITLE: <u>Tools for Measuring Training Effectiveness</u>

OBJECTIVE: Design and develop a tool to assess the extent to which each team member benefits from training as a team.

DESCRIPTION: An enormous development and implementation effort is necessary for large scale team-based training exercises, such as those planned for BFTT and JCTCS. These team exercises, among others, require performances from a number of different areas of specialized skill and knowledge. In order to maximize the training potential of these exercises, it is necessary to ascertain the extent to which individual team members benefit from training. This is

to assure that feedback/remediation can be targeted to specific areas and to assure that effective training occurs as specific interventions may have differential benefit on individuals based on background knowledge and position/role within the team.

Recent theorizing has suggested that team members who hold similar mental models will be able to predict each others' behavior, adapt, and coordinate with each other; team members who do not share similar mental models will not be as successful (Cannon-Bowers, Salas, & Converse, 1990). Therefore, measures that tap the extent to which individuals have overlapping mental models will aid in understanding the degree to which training has imparted appropriate cognitive representations. These measures, based in cognitive theory, should: (1) be sensitive to changes that occur as a function of learning; (2) characterize learning discrepancies between one individual and the next; and (3) identify specific areas where learning deficiencies exist.

PHASE I: Phase I will result in a functional description of a methodology for assessment of individual team member's understanding that allows for comparisons between team members.

PHASE II: Phase II will result in a prototype assessment methodology for a current team training program.

PHASE III: Phase III will result in the production of an assessment device.

COMMERCIAL POTENTIAL: Within a number of communities (e.g., commercial aviation, nuclear power plant operators, firefighters) increased emphasis is being placed on the training of teams, not just individuals. This methodology will allow for the assessment of these training programs and provide feedback for their improvement.

### N97-025 TITLE: Aircrew Ejection Windblast Protection

OBJECTIVE: Develop lightweight, deployable aircrew windblast protection devices for use in tactical aircraft emergency egress systems.

DESCRIPTION: Major injuries and fatalities experienced in high-speed tactical aircraft ejections include disruption of aircrew extremity joints, fracture of the skull, arms, legs, neck, and spinal transection. Current approaches to limb-flail protection, consisting of arm- and leg-restraint straps, encumber the aircrew while operating the aircraft. In addition, current ejection seats have no provisions for airflow stagnation devices to reduce and control windblast forces on the torso, head and neck of ejecting aircrew. The successful development of new technology for windblast protection devices would provide the Navy with a pivotal technology solution toward reducing major aircrew injuries and fatalities.

PHASE I: Develop alternative concepts for deployable aircrew ejection windblast protection devices, and determine the technical merit and feasibility of the most promising concept(s). The proposed concept must be unobtrusive during normal aircraft flight and deployed only at ejection initiation.

PHASE II: Demonstrate the concept(s) chosen during Phase I by constructing, testing, and evaluating prototypes to establish predicted performance in open ejection seats.

PHASE III: Transition the development to the Navy and Air Force joint Advanced Technology Escape System for use in the Joint Advanced Strike Technology aircraft.

COMMERCIAL POTENTIAL: The technology developed through the SBIR will have potential for use in other lifesaving and/or restraint equipment applications in boating, commercial aircraft, recreational aircraft, and automobiles.

# N97-026 TITLE: <u>New Materials for Advanced Performance</u>, <u>Fireball Heat Resistant</u>, <u>Emergency Egress Parachute Systems</u>

OBJECTIVE: Develop new textiles with increased resistance to damage and improved parachute performance characteristics.

DESCRIPTION: A need exists for the development of high strength, low bulk, energy absorbing, heat resistant textiles to enhance the performance of emergency escape parachute systems used in tactical aircraft. Damage to these parachutes during deployment or exposure to fireballs result in serious injuries and fatalities due to excessive descent rates. Current high strength, heat resistant materials have undesirable design characteristics such as high bulk and high

parachute opening shock. Improvements are also needed in reducing the rate of descent of existing emergency escape parachute systems without increasing the size and bulk of the parachute system.

PHASE I Conduct a study to determine if it would be more effective to develop new energy absorbent high strength heat resistant materials, or modify potential existing materials.

PHASE II Perform the following tasks: (1) Based on Phase I, develop new high strength heat resistant materials or modify selected existing materials (2) Produce materials in developmental quantities (3) Construct, test and evaluate prototype test items.

PHASE III Scale up selected Phase II materials to commercial production. Design, build, and test new high strength emergency egress parachute systems for use in Navy tactical aircraft.

COMMERCIAL POTENTIAL: Ultra-light aircraft, and personnel recovery systems. High strength cables, ropes and sails for sailing. Protective clothing for firefighters. Lightweight heat resistant fabrics for drapes and carpets. Smoke jumper parachutes.

## **REFERENCES:**

- (1) Art Karrer, <u>Data Trend Analysis Report for Navy Ejections (1976 Through 1989)</u>, NAWCWPNS TP 8111, March 1993
- (2) Bruce W. Trenholm, Major Causes of Mishap-Related Fatalities and Major Injuries 1987-1993, NAWCWPNS TP 8190, May 1994

### N97-027 TITLE: Non-Explosive Emergency Parachute Automatic Actuating Device (AAD)

OBJECTIVE: Explore development of a non-explosive Automatic Actuating Device (AAD) for use in Fixed-Wing Non-Ejection Aircraft Emergency Parachute Assemblies.

DESCRIPTION: Current naval Fixed-Wing Non-Ejection Aircraft use Emergency Parachutes that are automatically opened by a ballistic pack opening device. These ballistically timed and actuated devices restrict the repack (maintenance) cycles of the parachute assemblies to approximately two to three years because of the explosive charges used in them. Furthermore, if inadvertently activated, they require disposal or costly refurbishment. The repack of these parachute assemblies is also adverse to safe operation and keeps the operating costs of maintaining them high. Extending the repack cycle to a more acceptable logistics cost has been demonstrated in parachute assemblies without AADs, and is possible in the Fixed-Wing Non-Ejection Aircraft Community if a new Non-explosive AAD is developed. The new AAD would not require servicing or maintenance for a minimum of 10 years from when it is originally installed in the parachute assembly to realize the full logistics savings. Additionally extending the repack cycles of the parachute assemblies actually reduces the maintenance induced r rate caused during repacking; this is an additional benefit non-explosive AAD with a service life of at least 10 years.

PHASE I: Conduct a study to determine if the technology can be developed to produce a AAD with a minimum 10 year service life and is serviceable in the field if inadvertently activated.

PHASE II: Perform an effort to develop, fabricate, demonstrate, and validate a new AAD.

PHASE III: Qualification and retrofit of applicable naval parachute assemblies via a Class 1 Engineering Change Proposal (ECP).

COMMERCIAL POTENTIAL: Sport Parachuting, USDA Smoke Jumpers, and USAF Emergency Parachutes.

#### N97-028 TITLE: Ontimized Recovery Systems Control

OBJECTIVE: Develop technologies to optimize the inflation of parachute systems over a wide velocity range without exceeding acceptable drag force limits.

DESCRIPTION: Recovery systems for tactical aircraft must safely recover the ejecting aircrewman over a wide escape envelope; from zero speed-zero altitude (zero-zero) to speeds in excess of 600 knots. These velocity extremes place conflicting performance requirements on the recovery parachute system. For zero-zero ejections, it is desirable to

inflate the parachute as quickly as possible; however such rapid inflation at high speeds would result in catastrophic damage to the parachute and major injuries to the aircrewman. Conversely, delaying the inflation to meet high speed requirements would result in insufficient time to inflate the parachute for zero-zero ejections. The performance of current escape systems is compromised in the attempt to meet the entire escape envelop with a single system. Technology needs to be developed to minimize the inflation time of parachute recovery systems for all speed/altitude conditions without exceeding human tolerance limits.

PHASE I. Develop recovery and control system concepts that meet the requirements stated above.

PHASE II. Perform the following tasks: (1) Develop Level 2 drawings of most promising concepts; (2) Fabricate prototype test items; and (3) Test and evaluate prototype sub-systems. Validated concepts define transition to Phase III

PHASE III. Design and build recovery and control systems for use in Navy tactical aircraft. Evaluate these systems for emergency egress use (sled tests, in-flight ejection). Perform qualification testing with state-of the-art ejection seat technology. Scale up selected Phase II prototypes to commercial production.

COMMERCIAL POTENTIAL: Technology would be applicable for any application requiring regulated deployment of parachute recovery/retardation systems including delivery of emergency supplies, emergency recovery of private/commercial aircraft, deceleration of high speed vehicles, premeditated personnel jumping, recovery of test rockets or space delivery systems.

## N97-029 TITLE: Gas Turbine High Cycle Fatigue (HCF) Detection, Measurement and Control

OBJECTIVE: Develop innovative high cycle fatigue measurement, detection and control techniques applied to gas turbine compressor components.

DESCRIPTION: The U.S. Navy desires to consider advanced innovative HCF detection, measurement and control techniques for the use in gas turbine compressor components including spacers, stator vanes, blades, and disks. The technology developed needs to be capable of:

- 1. Detecting high order compression system vibrations in an operating engine.
- 2. Quantifying the life impact of the detected vibrations.
- 3. Controlling the vibrations by controlling flow path instabilities that are exciting the vibratory modes.

It should be compatible with recent developments in active stability control for compression systems. The possibility of combining active stability control with active detection and control of HCF should be explored. It should also be capable of recording information necessary to quantify the severity of the phenomena in terms of component life impact.

PHASE I: Provide conceptual designs for actively measuring and controlling high cycle fatigue. The designs should be generated and validated through theory, analysis, simulation, and subscale testing.

PHASE II: Fabricate full scale designs for experimental verification the concept.

PHASE III: Transition to DOD/NASA 6.2/6.3 exploratory component development and demonstration program(s). Produce limited numbers of HCF detection and control systems for field demonstrations and validation.

COMMERCIAL POTENTIAL: HCF is a characteristic problem in all types of gas turbine engines commercial and military alike. The commercial aerospace industry would benefit from the reduction of HCF related maintenance problems.

# N97-030 TITLE: In-Field Composite Damage Assessment

OBJECTIVE: The objective of this sub task is to identify and address non-destructive technologies for assessing damage of in-fleet composite rocket motor cases/airframes. This type of damage assessment capability will provide a means for the fleet to verify damage to missile systems and composite aircraft structures incurred during anomalous service conditions.

DESCRIPTION: Due to their laminated construction, the most common mode of failure in composite materials is interlaminar fracture or delamination. This type of failure usually occurs within the laminate and is not normally obvious during general visual inspections. This type of failure, if left undetected, can have a significant effect on the engineering properties of the composites. This type of degradation can and will prove fatal if left undetected and poses a serious threat to ordnance personnel, aviators, aircraft and ships.

During manufacture and assembly composite cases/airframes are subjected to rigorous quality inspection in order to verify the integrity of the finished component. Once the system is placed onto the fleet this same level of product inspection is no longer available. Damage to composite cases/structures is not always visually obvious for the reasons pointed out in the previous section. As a result, non-destructive examination represents a critical step required to define both the extent and type of damage in composites.

Ideally, what is needed for the fleet is a portable non-destructive technique for damage assessment that can provide real time data and be employed under any circumstances whether the missile system is hung from wing of an aircraft or in its storage container.

One example is thermal imaging which is relatively new for non-destructive testing of composite materials. Thermography can be conducted through a variety of techniques, but the video-thermographic camera is the most efficient and provides the highest resolution. Thermography has been used by a number of investigators to detect and analyze damage in composites. Thermal gradients are generated using either passive or active method to delineate defects or damage.

PHASE I: This effort will first conduct a survey of current non-destructive technologies. Emphasis will be placed on the system that is most suitable for fielded operations. This technology must provide a means for in-fleet damage assessment of composite materials, eliminating guess work, speculation and costly NDT. The system will be readily portable.

PHASE II: Design and demonstrate shipboard portable NDI system identified under the Phase I SBIR effort. The system meeting the requirements for fielded operations will be evaluated first through Laboratory demonstration.

PHASE III: Produce and verify the shipboard portable NDI system by evaluation under real conditions (initial simulated environments) and finally under actual fleet operations.

COMMERCIAL POTENTIAL: A portable non-destructive technique for damage assessment that can provide real time data and be employed under any circumstances is ideal for commercial aircraft maintenance facilities as well as manufacturing assembly lines for on-the-spot component verification and quality control.

## N97-031 TITLE: <u>Increase Aircraft Firefighter Visual Acuity</u>

OBJECTIVE: To develop wrap-around transparent face protective equipment that is more durable (less susceptible to abrasion) and meets or exceeds infrared protection testing requirements in accordance with NFPA 1976.

DESCRIPTION: Currently, Navy and Marine Corp Aircraft Rescue FireFighters (ARFFs) use transparent face protective equipment developed in the 1950s. The present visor is a transparent polycarbonate material: type I, grade A, clear, 0.007 (+/- 0.015) inch thick or equal and is coated with the anti-fog coating "Izonex". It provides protection to the firefighter's head, face, and neck areas against radiant, convective, and conductive heat. The present transparent protective face equipment is easily scratched and difficult to maintain, requiring frequent replacement.

PHASE I: Conduct a feasibility study which develops transparent material/face protective equipment that will increase visual acuity (safety) of ARFFs and facilitates maintainability. The material must be easily fitted to existing headgear.

PHASE II: Test and demonstrate the protective face equipment.

PHASE III: Produce the protective face equipment

COMMERCIAL POTENTIAL: New protective face equipment could be used in the civilian firefighting arena.

REFERENCES: National Fire Protection Association (NFPA) Standard 1976

N97-032 TITLE: NDE of Marcelling in Composites

OBJECTIVE: Develop a method and system for identifying and quantifying marcelling (fiber waviness) in composite materials.

DESCRIPTION: Multiple failures in composite parts have been attributed to marcelling. The manufacturing processes (filament winding, fiber placement, and hand lay-up) for these parts often create "wrinkles" in some of the internal plies of the laminate. These marcels can cause localized redistribution of stresses resulting in failure of the part.

PHASE I: Manufacture reference panels containing out-of-plane marcels of varying severity. Previous efforts of characterizing these defects defined severity by the aspect ratio of the marcel. Design an NDT technology capable of detecting marcelling without the use of tracer fibers.

PHASE II: Develop Phase I technology and correlate NDT results to the geometry of the marcel. Determine the effects of varying degrees of marcelling on the ultimate strength of the composite.

PHASE III: Correlate the NDT results to design knockdown factors.

COMMERCIAL POTENTIAL: This nondestructive inspection technology would be a useful tool for evaluating marcelling in newly manufactured, fiber/matrix composite materials which are used in structural applications.

#### REFERENCES:

- 1. MIL-Q-9858
- 2. MIL-I-6870

#### N97-033 TITLE: Composite Moisture Sensor

OBJECTIVE: Develop a moisture sensor for quick "dry" or "not dry" decisions when repairing advanced composite parts using bonded techniques.

DESCRIPTION: Elevated temperature (above 250 degrees F) of the parent laminate or honeycomb structure require by cure/bonding/cobonding of advanced composite repair details (patches, adhesives) will usually result in blown skins (i.e., the skin separates from the core in large areas due to failure of the adhesive/core node bond caused by higher pressure of the heated moisture trapped in the core). Traditional methods for removing surface moisture require extended drying cycles (48 hours is typical) that are experience based and are not related to the actual moisture on the part or the maximum moisture acceptable before problems develop.

PHASE I: Identify preliminary design concept for Composite Moisture Sensor.

PHASE II: Perform detail design, fabricate and test a prototype system to confirm design projections.

PHASE III: Design and fabricate a full size, flight qualified Composite Moisture Sensor for installation in the V-22 aircraft. Provide installation and test support. Evaluate performance of system following test.

COMMERCIAL POTENTIAL: Commercial aviation has a major problem with moisture in honeycomb composite structures. Blown skins are common, resulting in excessive downtime to repair major damage that started out as a minor repair. The long drying times required to ensure dry structures before repair begins is also not acceptable

REFERENCES: V-22 Standard Repair Manual

#### N97-034 TITLE: Destruction of Hazardous Wastes using Solar Energy

OBJECTIVE: To design, demonstrate, and construct a hazardous waste destruction facility that uses incident solar radiation to decompose organic wastes, which traps or destroys toxic byproducts in a manner which reduces the total quantity of hazardous material requiring disposal, and does so in a manner that meets all applicable environmental regulations for waste stream treatment.

DESCRIPTION: There is much concern over waste management practices which dispose of hazardous waste material in landfill areas. The dwindling availability of such landfills and their potential future hazards from toxic seepage into the environment make the reduction of landfill practices necessary. Incineration is a viable alternative to landfill disposal of organic waste, but is often inefficient and neither economically nor politically feasible to build and maintain. Current hazardous waste incinerator technology requires the expenditure of large amounts of energy in order to attain and maintain the high temperatures (2000° to 3000°F) required for the pyrolysis of organic matter. Conventional technology achieves these temperatures through the combustion of fossil fuels or the use of other non-renewable resources

Recent DOE research has used solar furnaces to focus solar radiation and obtain temperatures in excess of those needed to pyrolyze organic matter. It has been demonstrated that this technique can destroy organic materials through both pyrolytic and photolytic mechanisms. The energy source for such a furnace is sunlight, a readily available and renewable resource.

This SBIR topic involves the evaluation of interfacing solar furnace designs to particle and toxic gas scrubbing technologies to achieve an efficient and inexpensive alternative to the destruction of organic hazardous wastes. Should such technology prove to be feasible both scientifically and economically, this work will continue with the construction of lab scale and finally a pilot scale facility.

PHASE I: Provide a feasibility study which examines the applicability of destroying a typical organic waste stream through absorption of concentrated solar radiation. This study will also examine available technologies for concentrating solar irradiance and cleaning up anticipated exhaust products. Limited laboratory scale tests may be needed to verify the dependability of the proposed techniques.

PHASE II: Construction and demonstration of a laboratory scale incinerator using information developed from the Phase I study.

PHASE III: Construction of a pilot plant scale solar combustion facility at a Navy shore facility.

COMMERCIAL POTENTIAL: Disposal options for hazardous wastes are becoming harder to find. The "cradle to grave" approach taken by environmental regulations and the increasing costs of hazardous materials disposal make total destruction of hazardous materials a viable option. Even non-hazardous wastes are taxing our current means of disposal. In 1992 it was reported that close to 130,000,000,000 tons of municipal waste is disposed of in landfills in the United States each year. Unfortunately, the most prevalent technique currently in use for destroying organic wastes, incineration, has acquired a poor reputation as a result of the production of PCB's, PAH's, and dioxins as byproducts of the process cool down. The ability of photolytic decomposition to occur at the lower temperatures where these compounds form from combustion products makes it unlikely that they would be found in the exhaust stream from a properly designed solar incinerator.

It is envisioned that small units could be built that would allow transportation of the incinerator to remote contaminated sites to assist in the cleanup of spills. Such a device may also prove useful in the destruction of waste material in space, where electrical power is minimal and at a premium. Solar incineration could also play a role in processing inorganic wastes into a form more easily handled, such as the transformation of friable and highly hazardous asbestos fibers into non-hazardous glass-like globules that could be subsequently recycled into construction media such as concrete or asphalt replacement on roads.

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- 4. "Insights from the Operation of Solar One and their Implications for Future Central Receiver Plants", Gregory J. Kolb, Daniel J. Alpert, Charles W. Lopez, Solar Energy 47, 39 (1991).
- 5. "Complex, Costly Cleanups May Snarl Base Closings," Dam Morain, Los Angeles Times, Tuesday, June 19, 1990, p. A1, A22-23.

## N97-035 TITLE: Spatial Light Modulation Technology for Training Applications

OBJECTIVE: To design and develop a full color, 2K x 2K pixel resolution head-mounted display (HMD) based on spatial light modulation (SLM) technology. The HMD shall be capable of displaying conventional full color stereoscopic (2K x 2K pixels per eye) imagery at 60 Hz, and 1K x 1K pixel (per eye) full color three dimensional imagery at 1 Khz frame rates. The HMD shall include electronic circuitry suitable for interfacing to commercial image generation equipment.

DESCRIPTION: Spatial Light Modulation (SLM) technology has the potential for high resolution, high brightness, small size, light weight, and extremely high frame rates (up to 10,000 frames per second). However, existing SLM devices lack the supporting electronics to interface to sophisticated computer image generation equipment. Optical designs are also lacking to efficiently integrate reflective SLM devices into collimated head-mounted display systems. Furthermore, technology is needed which can take advantage of the high frame rate capability of SLM devices to create three dimensional images in HMD's.

PHASE I: Design analysis on existing and prospective optical components, three dimensional imaging technologies, and image generator interface methodologies.

PHASE II: Implement the chosen design, and demonstrate the HMD's effectiveness by integrating it with an existing military simulation.

PHASE III: Commercialize the prototype system developed and evaluated in the Phase II effort.

COMMERCIAL POTENTIAL: The proposed technology development has the potential to enhance the fidelity and affordability of a broad range of head-mounted display applications, including commercial simulation and training, remote handling, education, virtual reality and entertainment.

# N97-036 TITLE: Adjustable Collimation for Head-Mounted Displays.

OBJECTIVE: To develop and implement technology to allow the collimation distance in stereoscopic head-mounted displays to be adjusted between approximately one meter and near infinity.

DESCRIPTION: A system is required to allow readjustment of image collimation distance for different training tasks and application using the same head-mounted display. Studies have shown that having the correct collimation distance setting can enhance the effectiveness of stereo imagery as much as one-hundred fold. The correct collimation for a specific task is the distance from the eyepoint at which the primary objects of interest in the simulated environment are located. By causing the perceived distance of the imagery to be at the same effective distance as critical simulated objects produces a significant increase in sensation of depth. Existing head-mounted displays have a fixed collimation distance, and therefore have limited effectiveness in a wide range of training tasks and applications. For example, a head-mounted display with a near infinity collimation distance is appropriate for far range flight simulation tasks, but is ineffective for close range tasks such as aerial refueling.

PHASE I: Identify alternative design approaches, and conduct cost/performance trade studies.

PHASE II: Implement the chosen design(s), and conduct extensive evaluation of training effectiveness and simulation sickness issues in one or more military simulation applications.

PHASE III: Commercialize the prototype system(s) developed and evaluated in the Phase II effort.

COMMERCIAL POTENTIAL: The proposed technology development has potential to enhance the fidelity of a broad range of head-mounted display applications, including commercial simulation and training, remote handling, education, virtual reality and entertainment.

# N97-037 TITLE: Stiff Micro Force Transducer with High Frequency Response

OBJECTIVE: Develop a sensitive force transducer for use in measuring oscillating thrust of combusting propellant samples in the laser recoil experiment. Current transducers are too heat sensitive, too low resonant frequency or not sensitive enough to small force oscillations, Ideally, it would be insensitive to pressure oscillations.

DESCRIPTION: The purpose of this SBIR is to increase the basic understanding of ignition transients and combustion oscillations in solid propellant rocket motors, including experimental work on laser-augmented combustion of solid propellants. Specific experimental data is the propellant thrust response to laser power oscillations using a microform transducer at atmospheric and elevated pressures, up to 200 psi,

The ideal microforce transducer would be small (less than 3 inches in any direction, have low sensitivity to heat (from the burning propellant), be sensitive to 0.01 gram force, be insensitive to pressure oscillations and have a resonant frequency above 1000 Hz. The Kistlor 9207 piezoelectric force transducer is fairly heat and pressure sensitive and not designed for elevated pressures. Although it has a resonant frequency above 10K Hz, when attaching the 1.0 gram sample pedestal and 0.6 gram sample it drops to 400 Hz.

There is a Russian inductive force transducers which has the required sensitivity, but the resonant frequency is only 160 Hz.

PHASE I: Design and produce 4 prototypes of the stiff microform transducer and associated electronics.

PHASE II: Refine the design and manufacture demonstration quantities (10) for other combustion research labs in government, universities, and industry for evaluation.

PHASE III: Refine the transducer for commercial use including operational manuals, and signal amplifiers, market at the Sensors Expo.

COMMERCIAL POTENTIAL: The transducer could have use throughout the propellant combustion community for both research and development by industry, government and universities. Also it could apply to biomedical, disk drive heads, robotic pick and place machines with tiny fragile components. The technology could be adapted for ultra high sensitivity hydrophones.

REFERENCES: Laser Recoil, Emission, and Flame Height Combustion Response of Oxidizers

## N97-038 TITLE: Registration of Forward Looking Imagery

OBJECTIVE: A methodology is sought for performing single frame image registration and template matching, in real-time, of images captured with a forward looking camera or sensor.

DESCRIPTION: Develop a method and system of performing image registration and template matching of images taken with a forward looking camera or sensor. Issues that will need to be addressed include, but are not limited to, range/scale, heading/orientation, aspect. This should be considered as a discrete process, where individual images need to be processed. The matching will be performed with a set of pre-defined templates. Performance of this operation should be deterministic and in near-real-time. A prototype implementation would be developed in C or C++ (commercial requirement) and should be able to run on equipment consistent with Navy combatant computer architectures. A comparison between classic image registration techniques and new approaches should be performed as part of the project.

PHASE I: Conduct a feasibility study and establish the processing requirements for performing the task. Develop algorithms and demonstrate them in a proof-of-concept prototype implementation.

PHASE II: Expand the Phase I study and demonstrate the concept within a fully operation prototype performing in near-real-time, e.g., seconds.

PHASE III: Enhance the prototype to interface with camera/sensor equipment, operate in real-time, and integrate it with existing and under development military systems.

COMMERCIAL POTENTIAL: Signature authentication, security systems, automated product inspection, image database querying.

REFERENCES: Gonzales, R. C. and Woods R. E., "Digital Image Processing", Addison-Wesley, 1992.

OBJECTIVE: The objective of this effort is to develop and implement new technology to minimize missile control fin hinge moment by tailoring fin structure and panform with passive and/or active fin profile control.

DESCRIPTION: Overall missile performance and range can be enhanced by minimizing control fin hinge moments while maintaining the aerodynamic normal force required for high "g" maneuvering. Recently, initial development of innovative technology has been conducted in the areas of flexible structure and platform optimization to satisfy specific aerodynamic objectives subject to geometric and other constraints. By combining and extending the existing technologies, it is now possible to perform parametric studies and conduct tests to explore new optimized structural concepts and platform shapes with passive and/or active profile control aimed at reducing actuator power requirements of missile control fins.

PHASE I: During the first portion of the program, for a given platform, parametric optimization studies will be conducted to define orthrotropic or anisotropic (such as composites) fin structures with suitable spanwise to chordwise stiffness ratios for controlling center of pressure location. In this process, suitable aerodynamic models will be employed in the optimization scheme depending on the flow conditions. The main purpose of the Phase I effort will be to demonstrate the feasibility of controlling fin hinge moment by passive profile control of a realistic composite fin structure and platform subject to flutter, geometric and other constraints. In addition, a Phase II plan will be formulated to extend the fin structural model to include piezoelectric elements, effects of platform shape in the optimization scheme, and the design of fins to be tested in a systematic wind tunnel program.

PHASE II: During the second portion of this effort, the Phase I optimization scheme will be extended to include active control (such as piezoelectric) elements in the structural finite element model as well as effects of platform shape. The enhanced optimization scheme will be used to perform parametric studies aimed at designing realistic fin structure(s) with the aerodynamic objective of minimizing hinge moment. Detailed trade-off studies will be made of the control efficiency and power requirements of the actuators of rigid, fully deflectable control fins, flexible fins with passive profile control, partially deflectable fins with active profile control, and nondeflectable fins with active profile control. On the basis of the information gained from the trade-off studies, fins will be designed using the enhanced optimization schemes. The claimed performance of the fins will be checked against CFD calculations.

PHASE III: During the third phase, wind tunnel models of the most promising designs will be built and tested.

COMMERCIAL POTENTIAL: A comprehensive design code capable of including effects of structure, platform, and passive and/or active profile control will be extremely useful to missile control fin and aircraft control surface designers. By incorporating suitable hydrodynamic flow model codes, the technology is equally useful to the design of control surfaces of submersibles. Likewise, the technology should be useful in the design of turbine blades and windmills. The multidisciplinary optimization design technology coupling aerodynamics, structures, and active controls has many "spin-off" applications.

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# N97-040 TITLE: An Optimized Design and Coupling Analysis Tool for Conformal Antennas on Treated Platforms

OBJECTIVE: Develop a CAD-based tool for design and performance evaluation of conformal antennas mounted on mobile or airborne platforms while taking into account nearby treatments (or non-metallic property) and coupling from other communication devices on-board the platforms for information and electronic warfare (IEW) applications.

DESCRIPTION: This effort addresses a need for conformal antennas design software which account for platforms curvature, material treatments, nearby discontinuities and coupling among various antennas for accurately assessing its radiation pattern, sidelobes, near-field characteristics. Of particular interest is also the modeling of the antenna feeding networks and array configurations which are important in optimizing received signal power over all incidence angles and the desired bandwidth. The proposed software should be interfaced with high-frequency methods for modeling the entire platform and with visualization software to permit an examination of the interactions and field strengths in the immediate antenna surroundings.

PHASE I Develop prototype software capable of conformal antenna plus feeding network design in the presence of treated and highly curved platforms. Software should demonstrate capability with validation for accurate prediction of near-zone fields and far-field radiation patterns.

PHASE II Full scale development and interface with high-frequency and visualization software for antenna system assessment onboard complex platforms. Deliver modeling software (with detailed manuals) which is fully validated and packaged in a user-friendly, menu-driven form.

PHASE III Interface with government off-the-shelf (GOTS) software and demonstrate the operation of algorithms in an synthetic virtual environment for IEW effectiveness evaluation.

COMMERCIAL POTENTIAL: In wireless systems, there is a pressing need for designing new antenna systems which account for near field effects and provide pattern reconfiguration. An analysis and design tool which includes curvature effects, nearby obstructions and can permit antenna shape/radiation pattern optimization has tremendous commercial potential in the re-design of cellular phone and personal communication wireless systems.

#### N97-041 TITLE: Next-Generation Real-Time Threat Simulator for Weapon and EW Systems Simulation

OBJECTIVE: Develop next-generation real-time threat simulators with high fidelity and accuracy in far- and near-field representations for design and effectiveness assessment of EW and weapon systems.

DESCRIPTION: This development focuses on innovative ideas and approaches in electromagnetic modeling and representation of complex radar targets which significantly improve the fidelity and accuracy of the current look-up table approach of threat simulator systems. The emphasis of this effort is to investigate and develop technology to produce new real-time radar threat simulator engine based on N-point scatterer models or any other novel comparable technologies. The technique developed should provide both far- and near-field (up to endgame scenarios) representations rapidly and continuously with very high fidelity and accuracy.

PHASE I: Explore and identify the accuracy of N-point scatterer model extraction processes with measured and/or predicted data and demonstrate the robustness on selected complex target. Show the validity of the approach employed along with computational speed and accuracy improvements.

PHASE II: Develop a visualization and computational engine based on the Phase I results to interface this capability into existing threat radar simulators. Demonstrate the computational speed and improved overall fidelity and flexibility of this new approach in a selected threat radar simulator.

PHASE III: Interface with GOTS (government of the shelf) software and demonstrate the operation of algorithms in a synthetic 3-D virtual environment for EW and weapon effectiveness evaluation.

COMMERCIAL POTENTIAL: This research and development effort has potential commercial applications in the development of NASA, FAA and airline training simulator systems with significant flexibility and accuracy enhancements. Current commercial radar simulators are also still utilizing 60's simulator technologies and this SBIR technology advancement would be a major improvement in commercial training and analysis simulators.

# N97-042 TITLE: <u>Integrated Multi-Spectral Modeling For Surveillance, EW and Mission Planning Applications</u>

OBJECTIVE: Develop a computer-based multi-spectral (EO/IR and Radar) sensor modeling and simulation capability for information and electronic warfare (EW) applications.

DESCRIPTION: The EW, mission planning, precision-guided weapons, and information warfare communities require much higher fidelity modeling and simulation data for the development of tactics and targeting selections in support of the warfighter. Various computational methods in predicting the multi-spectral sensor returns are becoming very reliable to estimate multi-spectral scattering characteristics of a variety of targets, terrain, regions, and sites. This effort will address the integration of real-time high fidelity multi-spectral simulation capabilities for improvements in EW/weapon analyses and assessments of complex operational end-to-end sensor systems.

PHASE I Explore and evaluate high-fidelity near real-time modeling techniques and provide an innovative plan for enhancing the multi-spectral simulation tools for surveillance and EW applications. Show the validity of the plan by demonstrating a near real-time synthetic aperture radar (SAR) and IR system that emulates various clutter, terrain, and sensor conditions for an actual data collection platform.

PHASE II Extend the modeling approach with multi-spectral tools to perform near real-time modeling and simulation of a multi-spectral (EO/IR and radar) information warfare virtual environment. The tool-kit must be capable of providing in-situ multi-spectral sensor, platform terrain and elevation realism to support a full 3-D simulation environment.

PHASE III Interface with GOTS software and demonstrate the operation of algorithms in an synthetic virtual environment for IEW/weapon effectiveness evaluation.

COMMERCIAL POTENTIAL: This research and development effort has commercial applications in the design of a general class of high fidelity 3D simulation technologies for interface to GIS systems. This high-fidelity data can be used by the USGS land management of office for environmental considerations, erosion analysis, land use analysis, environmental analysis and detailed modeling and simulation of urban microcell and macrocell wireless communications systems.

# N97-043 TITLE: Automatic Battle Damage Assessment in Remotely Sensed Imagery

OBJECTIVE: Develop automatic algorithms to quantitatively assess battle damage by detecting changes in time sequenced surveillance imagery of the battlefield.

DESCRIPTION: Timely battle damage assessment is critical in the modern rapidly evolving battlefield. Near real-time independent verification of a previous strike's success would allow more optimal planning of subsequent sorties. It also would thaw enemy attempts in counter-measures such as painting holes on the runway. Automated method of quantitatively determining target damage by comparing imagery of the target area before and after a strike would allow the processing a large volume of imagery quickly.

PHASE I: Conduct a study of battle damage assessment techniques. Determine the achievable performance such as false alarm rate and accuracy of the estimation of the size of the damage etc. as a function of imagery parameters and quality. Determine the time-line of the automated processes given a standard workstation hardware environment. Determine scaling properties as a function of imagery size, volume, and spectrum.

PHASE II: Complete algorithm and software development. Demonstration and characterization of performance on sample imagery.

PHASE III: Field demonstration using real-time data link and a flying platform.

COMMERCIAL POTENTIAL: Potential application in medical imaging for tumor detection complete with size estimation. This will provide an aid to independently flag any potential tumors in a central processing site.

## N97-044 TITLE: High-Performance Microwave Imaging and Target Recognition Techniques

OBJECTIVE: Develop high-performance techniques for microwave image formation and recognition with flexibility for wide range of system operating configurations.

DESCRIPTION: Conventional microwave imaging algorithms and target identification techniques are developed based on different assumptions and approximations in various components of the modeling process which often translates into limitations of system capability and reduction of overall performance. Therefore, it is of great importance to develop high-performance microwave image formation and target identification techniques which are capable of operating effectively under various system configurations and parameters such as illumination waveforms, antenna beam patterns, and near- and far-field schemes.

PHASE I: To conduct a complete study for the development of high-performance microwave image formation and recognition techniques. The full-scale analysis includes resolution, sensitivity, and computation complexity corresponding to the various operating modes.

PHASE II: To complete the development and software integration of high-performance microwave imaging and recognition techniques, and full-scale performance evaluation.

PHASE III: Full-scale field tests or demonstration in an equivalent virtual environment and subsequent modifications for optimal performance.

COMMERCIAL POTENTIAL: In remote sensing applications, microwave imaging often plays a very important role in modern medical imaging as well as in predicting, surveying and management of hazardous material waste, agriculture crops, forest and other natural resources. The R&D effort will greatly benefit civilian remote sensing applications and resource control and management as well as medical imaging.

# N97-045 TITLE: Laser Interferometer for TCLE Measuring of Polymeric Material

OBJECTIVE: To develop a laser interferometer designed to measure thermal coefficient of linear expansion (TCLE) of highly-filled polymers.

DESCRIPTION: The propulsion community currently uses various methods to measure TCLE, resulting in an experimental variability as high as 80% between government and private laboratories. Such discrepancies can result in very large errors in structural integrity and service life analyses of various propulsion systems. Therefore, the JANNAF Structures and Mechanical Behavior Subcommittee (S&MBS) has begun an effort in FY 95 to provide the community with a research procedural document to perform consistent TCLE measurements. In FY 95-96, JANNAF S&MBS conducted a round-robin within the propulsion community and found that each laboratory performs the test slightly different, even when using the same type of thermal mechanical analyzer (TMA). The results of the JANNAF FY 95-96 TCLE Round Robin indicated a real need to standardize the method and to develop a more precise way of measuring TCLE to minimize experimental variability between laboratories. The Navy has recently developed a laser interferometer sensitive enough to measure cure shrinkage during polymerization and validated a theory that cure shrinkage was one of failure mechanisms responsible for the HARM's bondline failures. During the failure investigation, the Navy discovered that the technique may have the ability to measure TCLE within some measure of accuracy. Therefore, the Navy is proposing an SBIR for a contractor to research and develop the technique to include TCLE.

PHASE I: Provide a feasibility study which develops a laser interferometer capable of measuring TCLE within +/- 0.00000001 in/(in·\_F). The device must operate within a temperature regime of -250 to 250 \_F at variable rates; therefore, an environmental chamber must be designed and integrated into the system. The complete system must have the ability to interface with either a MAC or a PC controller and data acquisition system.

PHASE II: Develop, test and operationally demonstrate the TCLE Laser Interferometer designed under the Phase I effort described in this SBIR.

PHASE III: Produce the TCLE Laser Interferometer demonstrated in the Phase II effort. This device will be transitioned into the JANNAF's Service Life Technology Program (SLTP), scheduled for up-start in FY 98.

COMMERCIAL POTENTIAL: New technique to be used in the Rubber and Composite Industry, along with the Defense Industry, and to increase the SOTA of Laser Technology.

REFERENCES: (CPIA paper)

### N97-046 TITLE: Local & Global Multiscale Feature Extraction Using A Library Of Wavelet Bases

OBJECTIVE: A methodology and system is sought for feature extraction, signal analysis and exploratory analysis in the setting where the objects (signals/images) have many dimensions (samples/pixels) and there are relatively few training samples and in the video setting where the volume of data is great and storage, retrieval and browsing requires special methods to be feasible.

DESCRIPTION: Innovative methodology and software is needed for applications in infrared (IR) imagery and radar signal processing. Problems to be addressed include interference rejection, clutter suppression, signal de-noising and classification, change detection, image registration and video browsing. This project will utilize over complete waveform dictionaries like wavelet packets to develop novel algorithms for feature extraction, classification and statistical inference in signals and images. The basic idea is reduce the dimensionally of the problem by using the packet framework and associated data structures for analysis and discrimination at different spatial and temporal scales. Algorithms that unify and bridge the gap between the packet data structure and the rules that specify classes including tests to classify coherent and incoherent signals are especially important. Due to the intrinsic difficulty in modeling the complex relationship between the sensor and the signal feature selectivity nonparametric statistical prediction will be a key priority. In particular, the methods should be integrated with classical and modern statistical pattern recognition tools (e.g., discriminate analysis, projection pursuit, or regression trees). Methods addressing non-Gaussian noise conditions using re-sampling techniques (e.g., the bootstrap, cross validation) are of interest. Also of interest are novel strategies for optimization of objective functionals (e.g., robust cost functionals) for classification. Scalability of the algorithms to handle large amounts of data in real-time is important.

PHASE I: Investigate novel techniques for wavelet packet statistical inference. The optimization of robust objective functionals for discrimination using overcomplete multiscale dictionaries will also be investigated. The unifying bridge between the rules specifying a class and the packet data structure will be thoroughly discussed. A plan for integration of the proposed software with existing development environments such as KHOROS\*, MATHLAB\*\* and S-PLUS\*\*\* is desired and possible preliminary analysis using test images will be encouraged.

PHASE II: Extensive software development and testing with signals and imagery with both commercial and military interest will be undertaken. Dimensionally reduction and feature discrimination using overcomplete waveform dictionaries will be demonstrated. Feature selection strategies, statistical connections and other analysis to support the pattern and signal processing software development will be required. Scalability of the algorithms to handle large amounts of data in real-time will be addressed. The methods should be implemented in a high level objected-oriented software language suitable for rapid prototyping of algorithms and exploratory signal analysis.

PHASE III: The technology has application in both the countermeasure arena as well as weapons seekers and rapid retargeting. A detailed description of the use is not appropriate in this format. To encourage commercial applications the software and the experimental results should be embedded in a hypermedia environment accessible from the world wide web.

- \*Registered Trademark of Khoral Research, Inc.
- \*\*Registered Trademark of Mathworks, Inc.
- \*\*\*Registered Trademark of Mathsoft, Inc.

COMMERCIAL POTENTIAL: Multiscale Analysis Has Application For Video Browsing & Image Classification In Digital Libraries. Time Frequency Analysis Is Applicable To Diverse Non-Stationary Signals Such As Speech, Medical And Mechanical Diagnosis.

REFERENCE: N. Saito & R. Coifman "Local Discriminant Bases", Wavelet Applications In Signal And Image Processing II, SPIE, Bellingham Wash., Vol. 2303, pp.-14

#### NAVAL SEA SYSTEMS COMMAND

N97-047 TITLE: Type 18 Periscope Heated Head Window

OBJECTIVE: Develop a Form-Fit-Function Replacement to the existing Type 18 Periscope Heated Head Window (HHW)

DESCRIPTION: The present Type 18 Submarine Periscope wire grid glass Heated Head Window was originally developed by Barr and Stroud and is now manufactured exclusively by Kollmorgen Corporation. It is extremely expensive to procure and has been the subject of a high number of failures over the last several years.

PHASE I: Design and develop an alternative to the existing HHW fabricated Head Window using Electro Conductive coating technology in lieu of the wire grid. Produce a prototype HHW for test and evaluation and design disclosure drawings.

PHASE II: Develop a additional designs that (first) utilize externally laminated thin layer EC coated Sapphire on a fused silica head, and (secondly) a HHW fabricated from a boule of pure Sapphire and, (thirdly) a design incorporating acrylic or other optically superior composite with mechanical integrity equal to or superior to the existing HHW.

PHASE III: The contractor shall prototype and test the Phase 2 designs. This Phase should develop Production level, full design disclosure engineering drawings adequate to support competitive procurement.

COMMERCIAL POTENTIAL: This design concept is applicable to windshields for commercial aircraft, helicopters, and ocean going ships, and face/vision protectors for emergency personnel.

REFERENCES: NAVSEA Drawing 887F050034, Cage 34228, Heated Head Window Assembly

N97-049 TITLE: <u>Diagnostic Measures of Complex Cognitive Skills</u>

OBJECTIVE: Develop an assessment tool to support deficiency-based training.

DESCRIPTION: The future Navy surface combatant will likely take advantage of significant technological advances in order to enable reductions in on-board manning. This will produce increased cognitive demands and added responsibilities upon the members of the resident crew. In addition, future Navy training is less likely to rely on formal shore-based facilities and more on shipboard training and on skill remediation. Given this reduction in manning and change in training focus, it is imperative that personnel be accurately characterized in terms of the skill and knowledge they possess. In this anticipated shipboard manning and training environment, the Navy will maintain a specific set of skills in the resident crew because the redundancy currently available in personnel will no longer exist.

In order to assure high levels of readiness are also maintained in this environment, there is a need for the development of cognitively based measures of learning. These measures shall be based in cognitive theory and must be robust enough to demonstrate predictive validity in both terms of predicting learning retention and in terms of predicting trainee on-the-job performance immediately following training. Further, these measures must accurately diagnose performance deficiencies in order for shipboard remedial training efforts to be prescribed. Finally, the application of these measures must be user friendly to be used effectively by shipboard personnel.

These measures, based in cognitive theory, must demonstrate predictive validity in terms of trainee on-the-job performance immediately following training and be robust enough to predict learning retention. Further, these measures must accurately diagnose performance deficiencies in order for shipboard remedial training efforts to be prescribed. Finally, the application of this assessment tool must be user friendly to be employed effectively by shipboard personnel.

PHASE I: Develop cognitively based measures of learning applicable to training in the Naval shipboard environment including a functional description that provides (1) a methodology for assessment of higher order cognitive processes, and (2) the manner in which this methodology will be used to support training. Report the results.

PHASE II: Design, develop, demonstrate and test a readily reconfigurable brass-board model assessment tool that applies the Phase I learning measures to one or more specific shipboard position(s), and may be applied to other shipboard positions by reconfiguration in the shipboard environment.

PHASE III: Phase III will result in the production of an assessment device and corresponding guidelines and specifications for use.

COMMERCIAL POTENTIAL: This methodology will have applications to any organization in which high performance skill retention is a problem and remedial training is applicable.

N97-050 TITLE: The Use of Virtual LANs (VLANs) for Multiple Level Security (MLS)

OBJECTIVE: Develop a methodology of reliably separating and segregating multiple security levels within shipboard and shore-based Navy local area networks (LANs) using virtual LAN (VLAN) technology.

DESCRIPTION: Navy shipboard and shore-based systems are migrating from multiple, independent "stovepipe" subsystems that are point-to-point connected or connected via individual dedicated shared-media (Ethernet or FDDI) LANs, to shipwide (or basewide) backbone networks that use switched (vice shared-media) LAN technology, e.g., switched-Ethernet, switched-FDDI and cell-switched ATM. The fact that the individual subsystems that are now to be integrated via a common backbone network operate at different security levels is a major concern and an impediment to a smooth, cost-effective integration.

The analogous problem of separating and segregating different user groups (e.g., design, manufacturing, sales, payroll, etc.) within a commercial LAN application has lead to the development of a number of proprietary methods of "virtual LANs" or VLANs. Early VLAN limitations, such as the need for all members of a given VLAN to be connected to the same LAN hub/switch, have given way to flexible architectures which propagate VLANs over FDDI and ATM backbones such that VLAN membership can be distributed throughout the entire network.

The use of the concept of VLANs to separate and segregate different security levels in a military LAN would be an ideal solution to the MLS problem if it could be done in a reliable and secure manner. In commercial applications of VLANs, the need for rapid and easy moving of people between different virtual LANs has lead to network management concepts that emphasize ease of reconfiguration over the stability and security of mandatory separation of security levels. Also, the need for high-performance switching has lead to short-cuts such as examining only the first frame of a new session to determine VLAN membership and switching subsequent frames (or cells) without reverification of VLAN membership. These factors result in the concern that accidental or malicious changes in addressing could result in an unclassified workstation being joined to a secret VLAN.

What is needed is a secure, reliable technique for assigning workstations (or, preferably, multiple persons who share a common workstation but who log in at different security levels) to their proper VLAN. Furthermore, the technique should use a secure, reliable technique for tagging all frames, and verifying the tags, to assure that VLAN members stay in their assigned VLAN. From the workstation user's point-of-view, VLAN membership should be mandatory, and not discretionary, and moving between VLANs should be outside the control of any user who did not have the special access privileges of the security administrator.

PHASE I: Evaluate current proprietary and evolving standards for VLANs, and the means by which VLANs are defined in network management workstations and implemented in Ethernet/FDDI/ATM switches. Propose modifications or extensions to a COTS VLAN technique that improves the robustness of the VLAN definition and separation technique such that it could be used to separate security levels in Navy LANs. Document the results in a report that (a) describes the proposed secure VLAN concept, (b) analyzes potential techniques for accidental or malicious breakdown of the security separation, and (c) identifies means by which the proposed VLAN security extensions might be submitted to appropriate standardization committees.

PHASE II: Demonstrate the proposed secure VLAN concept via laboratory hardware/software, preferably via modified COTS switching products.

PHASE III: Transition the secure VLAN technology into the commercial marketplace, possibly as options or extensions to COTS switching products.

COMMERCIAL POTENTIAL: There are a number of commercial applications of VLANs wherein the need for secure separation transcends the desire for ease of "moves and changes" or the desire for maximum throughput. These applications, such as the protection of medical records, the security of fund transfers, etc. would welcome the improved security of VLAN separation that will be provided by this SBIR development.

#### REFERENCES:

- (1) LAN Emulation Over ATM V1.0 Specification Document No. AF-LANE-0021.000
- (2) LAN Emulation Client Management V1.0 Specification Document No. AF-LANE-0038.000

These documents may be ordered from the ATM Forum at URL HTTP://www.atmforum.com/atmforum/spec order.html

N97-051 TITLE: Spherical Angular Function (SAF) Analysis Models for Integrated Antenna/Composite Structures

OBJECTIVE: Develop, validate, and demonstrate a synergistic suite of near-field computer codes based on the Spherical Angular Function (SAF) technique for efficient analysis and design of integrated electromagnetic sensor/composite mast performance and Radar Cross Section for advanced composite/metallic topsides of Naval surface vessels.

DESCRIPTION: The topside of future surface ships will increasingly utilize multilayer composite structures and antennas that are intimately integrated with the composite structures. In particular, the antennas will typically be either enclosed or embedded in the composite structures. Electromagnetic engineering tools are not useable for current EM design and analysis of the integrated topsides to insure that the total RCS of the antennas plus composite structures satisfies topside electromagnetic signature requirements while the antenna systems simultaneously meet the ship's electromagnetic surveillance, compatibility, and radiation hazard (RADHAZ) specifications. A suite of computer codes based on the Spherical Angular Function (SAF) technique has proven to be very effective for analyzing installed antenna electromagnetic effectiveness in today's mostly metallic topside environment. However, in its current form it is not suitable for progression toward composite/metallic structure integration. The SAF technique is capable of being adapted to aid in the design and analysis of future composite/metallic topside integration. The suite of SAF near-field codes to be developed for antennas operating on composite/metallic topsides should utilize adaptive asymptotic SAF near-field spectral analysis techniques to efficiently and accurately predict 1) far-field antenna pattern performance and antenna gain loss, 2) near-field radiated electromagnetic fields and antenna-antenna coupling, and 3) the monostatic and bistatic RCS contributions of the installed antennas and the associated composite/metallic structures. The composite structures that must be analyzed include both flat and curved multilayer dielectrics and frequency-selective surfaces (FSSs) configured as radomes or radar absorbing structures (RAS). The types of antennas to be analyzed include enclosed and embedded planar and curved arrays of printed-circuit antennas and waveguide arrays, as well as enclosed reflector, horn and traveling wave antennas.

PHASE I: Develop the adaptive asymptotic concept applied to the SAF scattering models to efficiently analyze scattering by polygonally-shaped and elliptically-shaped multilayer composite plates, and validate the computer model predictions for a) antenna pattern performance and gain loss, b) near-field radiation and antenna coupling, and c) monostatic and bistatic RCS against government-furnished measured data.

PHASE II: Develop the adaptive asymptotic SAF scattering models for both the interior and exterior scattering problems for the following scenarios for both enclosed antennas and embedded antennas of the types delineated above, as appropriate: 1) general "n-gon" cross-section composite masts comprised of polygonally-shaped multilayer composite plates; 2) cylindrical multilayer composite structures; 3) general curved multilayer composite structures. Validate the SAF computer model predictions against government-furnished measured data for a) antenna pattern performance and gain loss, b) near-field radiation and antenna coupling, and c) monostatic and bistatic RCS for shipboard integrated antenna/composite mast structures. Provide comprehensive "hands-on" training for using the SAF models for designing and analyzing integrated antenna/composite mast structures.

PHASE III: Develop, validate and demonstrate a Hybrid SAF/Finite Difference Time Domain (FDTD) computer model for integrated antenna/composite mast structures to expedite detailed design and analysis of ultra-broadband CW and pulsed multifunction, shared-aperture, embedded antenna arrays. Transition the SAF and Hybrid SAF/FDTD models to commercial and government customers.

COMMERCIAL POTENTIAL: The computer models will have important applications for the design and analysis of integrated antenna/composite structures for the commercial telecommunications and remote sensing industries, satellite tracking installations, airport traffic control radars, and space station platforms.

REFERENCES:

- 1. B.J. Cown and J.P. Estrada, "SAF Analysis of Shipboard Antenna Performance, Coupling, and RADHAZ in Complex Near-Field Scattering Environments," IEEE AP-S Symposium Proceedings, June 1995.
- 2. B.J. Cown and J.P. Estrada, "Shipboard Directive Antenna Modeling via the GMULT/GCUPL Computer Codes," Final Technical Report, GMT-9301 and GTRI A-9275, P.O. #'s NCEE/A303/10-92 and 10A-92 (Navy Prime Contract N-60921-92-D-A303), March, 1994.
- 3. B.J. Cown , J.P. Estrada, Brian L. Shirley, and C.E. Ryan, Jr., "Shipboard Near-Field Energy Determination," Final Technical Report, GMT-9101 and GTRI A-8963, Task SCEEE-NSWC/91-0123 (Navy Prime Contract N60921-87-D-A315-0123), September, 1992.
- 4. B.J. Cown and C.E. Ryan, Jr., "Near-Field Scattering Measurements for Determining Complex Target RCS," IEEE Trans. Ant. and Prop., Vol 37, No. 5, May 1989, pp. 576-585.

# N97-052 TITLE: <u>Fiber Optic Sensor Multiplexer using Microelectromechanical Systems (MEMS)</u> <u>Technology</u>

OBJECTIVE: Design and demonstrate a method of optically multiplexing at least 32 passive fiber optic sensors. The multiplexer shall be small, lightweight and will incorporate MEMS technology.

DESCRIPTION: The ships of the future will have an enormous number of sensors on board, perhaps as many as 250,000. A sensor system incorporating these sensors must be immune to electromagnetic interference (EMI) and possess the computing power to manipulate the data received from the sensors. One means of achieving this with an optically multiplexed passive fiber optic sensor system. With this system many passive fiber optic sensors can be tied optically to one source and one detector, thus reducing the cost of the system. At least 32 sensors must be multiplexed together and the resultant signal must be compatible with state of the art processing equipment.

PHASE I: Determine the feasibility of designing a fiber optic sensor optical multiplexer using MEMS technology.

PHASE II: Demonstrate a small scale, optically multiplexed fiber optic sensor network.

PHASE III: Construct a medium scale optically multiplexed fiber optic sensor network suitable for test evaluation on board a Navy ship.

COMMERCIAL POTENTIAL: This system could be used to monitor power plants, industrial processes and systems on board civilian aircraft.

#### REFERENCES:

- 1. Jacobson, Carl P. "Shipboard Fiber Optic Sensors", Proceedings of the Armed Forces Communications and Electronics Association Fiber Optics Conference, McLean, VA, March 1994.
- 2. Dakin, John, and Brian Culshaw, Optical Fiber Sensors, Vol I and II, Artech House, Boston, 1988.
- 3. Wolfbeis, Otto S., Fiber Optic and Chemical Sensors and Biosensors, Vol I and II, CRC Press, Boca Raton, FL, 1991.
- 4. Boyd, Joseph T., (Ed), Integrated Optics, Devices and Applications, IEEE PRESS, New York, 1991.
- 5. Wong, Ka-Kha and Manijeh Razeghi, (Ed's), Integrated Optics and Optoelectronics, SPIE Vol CR45, Bellingham, Washington, 1993.
- 6. Righini, Giancarlo C. and David Yevick, (Ed's), Linear and Nonlinear Integrated Optics, SPIE Vol 2212, Bellingham, Washington, 1994.
- 7. Edgerly, David E., Optoelectronics, TECHNOMIC Publishing Company, Inc., Lancaster, PA, 1995.
- 8. Web Site http://mems.isi.edu
- 9. Web Site http://kraken.nwscc.sea06.navy.mil/sc21/html/sc21.html

# N97-053 TITLE: Distributed Integrated Data Interface & Management System

OBJECTIVE: Develop a distributed integrated information data access system, in a application, operating system, and platform independent manner. The resulting system should provide a framework and method for integrating, managing, and controlling information resources in a secure and scaleable manner.

DESCRIPTION: Shipboard information systems, such as combat planning, power projection, navigation, and logistic systems, are deployed on a heterogeneous collection of platforms, operating systems, and data processing systems. Modern enterprise wide applications rely on combining information from these disparate systems into an integrated application fulfilling higher level shipboard missions. Regardless of shipboard mission there is a common need to manage and integrate these distributed heterogeneous information systems in a secure, and scaleable manner. In order to provide effective information management and access to this pool of information resources, it is necessary to establish an underlying management system architecture, and corresponding data access methods, focusing less on individual approaches to security, data distribution, and data interchange, and more on providing a generic framework that can be "plugged" into by COTS and GOTS products, and used to encapsulate individual management policy and data access functionality. The result of this development will be a deterministic, evolvable information architecture, and an open/standardized method of providing data interchange, as well as a rich set of developmental tools, and APIs useful for rapidly deploying this methodology to the information management field.

PHASE I: Investigation of proposed concept. Evaluate current and emerging system independent information management and integration technologies. Develop a simulation of this information management framework to establish the feasibility of the management architecture.

PHASE II: Demonstration of the proposed concept integrating several lab based networked applications. The demonstration should show the system/protocol/vendor independent management of these systems, as well as the ability to access data from these heterogeneous information sources.

PHASE III: Scale the lab based system into a larger shipboard application to demonstrate the data interchange between systems such as JMCIS, NTCSS, TAMPS, TSCM, TOP SCENE, or APPEX. Evaluate the effectiveness of this approach, as well as the realized developmental cost savings.

COMMERCIAL POTENTIAL: Modern Information Technology (IT) systems are developing integrated applications, that combine the functionality of various networked systems. The ability to develop higher level functionality on top of existing heterogeneous IT systems will provide the commercial sector with an opportunity to automate their workflow, and reduce the cost of doing business. For example, the healthcare industry can benefit, by developing applications that can integrate the processing steps associated with a patient visit, including patient records, treatment history, insurance information, and scheduling. This type of system will provide a common interface that will enable enterprise applications to access data regardless of the type of database engine the data resides in, and to manage that information in a similarly system independent manner. This common interface approach will reduce future developmental efforts by eliminating the requirement of having a single fully integrated database to cover all data elements, and allows organizations to recover some of the costs used to deploy legacy systems.

### N97-054 TITLE: Missile Fuel Leak Detection

OBJECTIVE: This concept is to develop, through new research and development, a missile fuel leak detector for use with current and future missile types.

DESCRIPTION: Current required capability (see ref. 1.) to detect liquid fuel resulting from a leak in a missile canister by missile systems such as the Vertical Launching System is lacking. Normal methods used to connect a fuel leak sensor inside a missile canister are inadequate and un-safe. Most electronic sensors are fundamentally electromechanical devices requiring voltage and current to function. The introduction of voltage and current into the volatile fuel vapors, no matter how small, can be catastrophic in that it can ignite the very liquid it is attempting to detect. New research and development to establish an advanced type of sensor to perform this necessary function in a safe manner is required. This sensor must not be capable of introducing electrical discharge when performing the missile fuel detection function.

PHASE I: Explore new research and development sensor technology capable of producing a sensing device as described which safely detects missile fuel and vapors.

PHASE II: New innovative methods identified from Phase I must then be developed into a prototype sensor. Test are to be run which proves that the new sensing technique is both safe and capable of detecting current and newly developed liquid fuels for missiles and torpedoes.

PHASE III: Integrate the prototype sensor into the existing Vertical Launching System for both the MK46 (S) Vertical Launch ASROC and the Tomahawk missile types.

COMMERCIAL POTENTIAL: A commercial application for this technology is in the Commercial Space Launch Industry, increasing safety during vehicular launch. Research and Development efforts in developing new fuels for commercial jets is another potential commercial area. This detector is applicable to any commercial industry using, storing, or handling highly volatile fuels.

# REFERENCES:

- 1. "Vertical Launching System MK 41 Canister Deluge Subsystem Safety Engineering Analysis Report," 28-OCT-83 (Draft version) page 2-2.
- 2. "Vertical Launching System Prime Item Development Specifications," WS20260A par. 3.2.1.2.1e

# N97-055 TITLE: All Optical Shipboard Sensing System

OBJECTIVE: Design and demonstrate a small scale model of an all optical sensing system for use in new ship construction

DESCRIPTION: The ships of the future will have an enormous number of sensors on board, perhaps as many as 250,000. A sensor system incorporating these sensors must be immune to electromagnetic interference (EMI) and possess the computing power to manipulate the data received from the sensors. One means of achieving this is an all optical sensing system. With this system, the sensing element, the connecting cable and the information processing unit will all be optical. This will require a merging of three technologies: optical sensors, optical computing and integrated optics. The goal is to have a sensing system entirely optical in nature and possessing extraordinary computing power.

PHASE I: Determine the feasibility of designing an all-optical sensing system. Demonstrate a system consisting of one sensor and the signal processing hardware.

PHASE II: Demonstrate a small scale all optical sensor network.

PHASE III: Construct a medium scale all optical sensor network suitable for test evaluation on board a Navy ship.

COMMERCIAL POTENTIAL: This system could be used to monitor power plants, industrial processes and systems on board civilian aircraft.

#### REFERENCES:

- 1. Jacobson, Carl P. "Shipboard Fiber Optic Sensors", Proceedings of the Armed Forces Communications and Electronics Association Fiber Optics Conference, McLean, VA, March 1994.
- 2. Dakin, John, and Brian Culshaw, Optical Fiber Sensors, Vol I and II, Artech House, Boston, 1988.
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N97-056 TITLE: Detection of Corrosion Under Paint

OBJECTIVE: Develop a reliable, portable means of detecting corrosion under paint in shipboard applications.

DESCRIPTION: Chipping and painting of shipboard structure is a routine maintenance function whose cost is minimized by accurate determination of need. A number of nondestructive (NDE) technologies have been tried over the years to detect corrosion under paint, including paints which discolor in the presence of corrosion, electrochemical detection, and ultrasonic surface wave approaches. A significant requirement exists to insure that the NDE method for detecting corrosion under paint is sufficiently user friendly that it can be used reliably by enlisted petty officers. The NDE method must also be portable and retain good detection capability in corners and tight spaces. Cost and training must be kept to a minimum while maintaining high probabilities of corrosion detection. The method should be robust for steel and aluminum substrates and a wide variety of common Navy paints and coatings. Surface preparation requirements should be kept to a moist towel wipe if possible. Battery operation is preferable, but if not the unit should be able to withstand common shipboard power fluctuations.

PHASE I: Demonstrate an NDE technology concept for detection of corrosion under paint. Conduct a notional design study with a goal of predicting NDE instrument size and detection probability in the final product.

PHASE II: Develop an operational prototype of the NDE of corrosion under paint system, and demonstrate in field trials aboard a ship of opportunity.

PHASE III: Utilize this equipment and techniques at Naval refurbishing centers and shipyards to lower costs associated repairing damage caused by corrosion on ships.

COMMERCIAL POTENTIAL: Automobiles, commercial vessels, near shore metal structures, and bridges all need a reliable means of detecting corrosion under paint. Millions of dollars in maintenance costs and in retaining structural integrity could be saved with a reliable NDE method for detecting corrosion under paint.

N97-057 TITLE: Advanced Display Techniques For Sonar Data Presentations

OBJECTIVE: Develop new techniques for the presentation of submarine sonar system information and acoustic data.

DESCRIPTION: Recent advances in commercially available signal processing hardware have provided submarines the ability to greatly expand the amount of sonar information processed at sea. Operator controls and displays have not evolved in a similar fashion. Managing this information has become a formidable challenge to the operator. In high contact density scenarios, operators can easily become overloaded which can result in missed detection opportunities at nominal detection ranges. Innovative data presentation techniques which provide intuitive and clear representations of the acoustic data are needed to reduce information overload to the operators. The target display platform for this application is capable of three dimensional display data rendering using the X-windows MOTIF Graphical User Interface Standard.

PHASE I: Develop innovative Sonar Data Presentation concept(s) founded on the GUI MOTIF Standard and the control and display methodologies of available Submarine Sonars. The performance capabilities of the innovative display must be superior to existing Sonar Data Presentations, permitting the operator to achieve better identification of targets and target tracks in less time and with less fatigue.

PHASE II: Design and fabricate a 'brass-board' prototype, and perform a proof of concept demonstration on selected display candidates developed in Phase I of this effort.

PHASE III: Based upon a successful Phase II effort, develop a prototype model for qualification, test, and evaluation and production purposes, including supporting software and documentation, for a control and display system which can be integrated into an existing submarine sonar system.

COMMERCIAL POTENTIAL: The potential for transferring this technology to commercial industry is high. Related applications include medical imaging, air traffic control radar systems, and potentially digital photographic image processing.

REFERENCES: None

## N97-058 TITLE: Develop a Generic Structural Composite Material to Meet MIL-STD-2031

OBJECTIVE: Develop a polymer matrix composite material that complies with MIL-STD-2031 and is suitable for all submarine non-pressure-holding structural applications.

DESCRIPTION: While it is generally accepted that polymer matrix composites represent an unlikely fuel source for initiating a fire; concern persists that in a fully involved fire, these materials will contribute to the available fuel load. Additionally, these materials typically outgas toxins during combustion. MIL-STD-2031 was developed as a means to provide guidance for addressing these issues.

The wide range of polymeric materials available suggest that it might be possible to design a plastic that offers flammability and smoke toxicity performance complying with MIL-STD-2031, while maintaining the strength required for structural applications.

PHASE I: Develop or identify those candidate chemistries that have the potential of providing products with the low smoke/vapor toxicities required. Include composite matrix materials and identify the toxic and non-toxic smoke/vapor by-products from literature search or direct experimentation. Identify the composite properties expected and possible synthetic routes to the product.

PHASE II: Synthesis of the candidate matrix compounds and lab-scale test and evaluation of their physical and fire performances.

PHASE III: This phase will consist of scale-up of the matrix material synthesis to pilot-plant or larger scale to provide materials for large scale evaluation of fire performance.

COMMERCIAL POTENTIAL: The most immediate commercial beneficiary of this development will be the aircraft industry. Smoke toxicity in aircraft fires is a hazard equal to impact hazard.

# **REFERENCES:**

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# N97-059 TITLE: Design of Optimal Outboard Electrical Cables

OBJECTIVE: Develop and demonstrate an innovative electrical cabling or electrical power routing system which provides extreme high reliability in an outboard rugged marine environment capable of withstanding damage from sharp metal objects.

DESCRIPTION: The need for a longer life (12 years minimum), high performance outboard cable or power routing system is required to assure the continued reliable operation of key mission area systems and support advanced technologies.. These cables or power routing concept may require armored coating as they are exposed to mechanical damage and heat, and are passed through the Main ballast Tanks or some form of hull penetrators. Consideration of dual jacket system is desired to benefit from the properties of the individual materials including mechanical damage toughness, water permeability, cable flexibility, water-block characteristics, manufacturability, shipboard installation, etc. Note, the cable system consists of cable lengths and connectors of various pin configurations and sizes including 3 to 85 pins and voltages which range from moderately high DC to moderately high AC..

PHASE I: Develop detailed recommendations and alternative preliminary designs for an innovative electrical cabling or electrical power routing system. The designs, should include technical, cost and schedule estimates and associated risks, and detailed plans to support the design, development and test of a prototype system are required.

PHASE II: Design, develop, fabricate and test a prototype outboard electrical system(s) based on results and plans delivered in Phase I.

PHASE III: Fully integrate the successfully demonstrated outboard electrical cabling or power routing system. Liaison with SBIR TPOC for land-based verification and validation and eventual at-sea testing.

REFERENCES: EBDiv Specification 2983J and others

COMMERCIAL POTENTIAL: Application is generic to the design and development of industrial equipment cabling used in marine structures and vehicles electrical systems exposed to liquid or spray and/or pressurized environments. In addition, design can be applied to any cabling application requiring high performance in an hostile environment.

REFERENCES: Weapons Systems Delivery Engineering Manual (WDSEM Vol V)

N97-060 TITLE: Compression Filter

OBJECTIVE: Develop a replacement for a mechanical (analog-electronic) compression filter. A mechanical design Compression Filter currently in use has demonstrated service for 20 years with a good technical performance, but a high failure rate and increasing repair costs. The compression filter is used to narrow the band pass in the IF (Intermediate Frequency) channel of a detection receiver. The basic principal of the mechanical filter is to delay the signal as the receiver sweeps proportionally to the rate the receiver tunes. This slows down signals as they enter the band pass and speed up signals as they exit, causing the signal to accumulate at the center band pass.

The awardee must obtain (or currently hold) a secret level facility clearance prior to contract execution.

PHASE I: Design, and develop a digital filter as a replacement for the mechanical compression filter in order to reduce cost and increase reliability. The replacement filter will digitally capture the IF and create an equivalent narrow band pass output.

PHASE II: Fabricate and test a prototype digital Compression Filter. The prototype will be subject to all current technical repair standard performance test (CW gain, System threshold & gain, Swept gain or loss, HF video pulse shape, Video dynamic range and CFP dynamic range) and a system performance test (HF acquisition, and CFP dynamic range).

PHASE III: Following successful completion of phase II, fabricate additional units of the Digital Compression Filter for fleet introduction. A purchase specification will be developed for Government purchase of Digital Compression Filter kits for fleet backfit.

COMMERCIAL POTENTIAL: All commercial radio receiving systems

REFERENCES: Lockheed/Martin Sanders DWG. 1098105G2

N97-061 TITLE: <u>Develop a Triaxial Gradiometer</u>

OBJECTIVE: This program will research and develop a Triaxial Gradiometer.

DESCRIPTION: Develop a new triaxial gradiometer to surpass existing gradiometers' performance limits and that will meet the future requirements for sensors in Closed Loop Degaussing. The X axis of the new gradiometer will be in the first Gaussian position (dHx/dx) with Y and Z axes in the second Gaussian position (dHy/dx and dHz/dx). Measurement of the gradients will support the capability to changing currents in coils and compensate for permanent magnetic fields as well as compensating for any inducing fields in a subject test specimen. Future needs exceed the current capabilities of this gradiometer. This work will extend the state of the art in gradiometers. Performance requirements (thresholds) for Phases I through III are as follows:

#### LINEARITY:

Each magnetometer is tested by increasing a collinear aligned field from -100  $\mu T$  to +100  $\mu T$ . A straight line is ran through the data points. The points are not to deviate by more than 7 nT from this line. Electronic or alternate methods of achieving linearity will be considered.

CROSS FIELD SUSCEPTIBILITY:

Each magnetometer is tested by increasing an orthogonally aligned field from -100  $\mu$ T to +100  $\mu$ T. A straight line is ran through the data points. The points are not to deviate by more than 0.9 nT from this line. Also the cross field rejection must be better than -54dB (20\*log(400/200,000)). Electronic or alternate methods of achieving cross field susceptibility will be considered.

PERFORMANCE:

Offset Error < 10 nT Offset Temp Coef<0.1nT/°C

Scaling Temp Coef <5 ppm/ °C

Spherical Turnaround Error <10nT gradient per meter rotated in 3 orthogonal planes

Perm Offset Max 2 nT per 20 Gauss Exposure

Bandwidth 0-50 Hz Flat

Calibration -

Scaling  $10V/G (100 \mu V/nT)$  for magnetometer

10V/G/baseline (100 μV/nT/baseline) for gradient

Accuracy  $\pm 0.6\%$ 

Initial Orthogonality ±.1°

Overall Range  $\pm 100,000 \text{ nT } (10\text{V})$ 

Internal Noise (0-10Hz) 25pT/root Hz

Environmental requirements (both goals and thresholds) are as follows:

ENVIRONMENTAL:

Operating Temp -10 C to 60 C Humidity 0 - 100%

ELECTRICAL:

Supply Voltage  $\pm 15$ VDC ( $\pm 14$ V to  $\pm 18$ VDC) Will not be harmed by reverse voltage

 $\begin{array}{ll} Total \ Current & <\pm 100 mA \\ Power \ Supply \ Rejection & <10 \ \mu V/V \\ Output \ impedance & <50 \Omega \\ Load \ tolerance & 10 M\Omega \ //\ 10 \ \mu F \end{array}$ 

EMI Susceptibility Insensitive to e-Fields over 59 Hz

### MECHANICAL:

- -VibrationEach core not move more than .005° when exposed 5 minutes to 20G RMS 20 Hz to 2 Khz
- -Drop Test3 feet all axes. Gradient alignment not to change more than 0.01 degrees.
- -spacingTwo triaxial magnetometers are to be spaced 12" to 14" from each other. Each core, in the triaxial magnetometer, to be within 0.5" of each other. Develop technology so that it is applicable to additional gradient baselines.
- -caseCores and associated electronics in one case not to exceed 152 cubic inches (The smaller, the better). This aids in shipboard mounting and cabling.

PHASE I: Design, develop, and provide a brass-board model of an innovative gradiometer design and indicate its feasibility in laboratory prototype tests and with theoretical analysis. Examine existing magnetic gradiometers to identify new materials and electronics technology to improve performance of the brass-board model.

PHASE II: Produce six prototype gradiometers for testing at sea, using the most promising technology as defined in Phase I. Performance parameters are to be optimized with low intrinsic noise, and low power consumption, low cost and ruggedness considered secondary considerations at this time. Rigorous testing will be performed and the devices will be characterized for production and studied for ruggedization and production cost reduction.

PHASE III: Produce gradiometers for production to Navy sensor requirements.

COMMERCIAL POTENTIAL: An advanced gradiometer will open new commercial markets in the areas of vehicle surveillance, traffic road sensors, and non destructive testing applications. Low cost magnetic gradiometer sensors would also be used for intrusion detection and surveillance systems.

### REFERENCES:

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- 2) Lentz, J.E., "A Review of Magnetic Sensors," Proceedings of IEEE, Vol 78, No. 6, June 1990.
- 3) Hooper E. T. and Hubbard W. M., "Development of the Ordnance Locator MK 15 (U)" United States Naval Ordnance Laboratory, White Oak, Maryland, NOLTR 66-219, 5 December 1966.
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#### N97-062 TITLE: Improved Mid-Frequency Statistical Energy Analysis Modeling Procedures

OBJECTIVE: Abatement of Airborne and Structureborne noise, through Development of improvements to statistical energy analysis (SEA) modeling procedures at mid-frequencies where high modal densities may not be present, and/or where individual modes of one or more components dominate the frequency response of a system or structure.

DESCRIPTION: Prediction accuracy in mid-frequency ranges from statistical energy analysis approaches has been noted as an area for needed improvement and accuracy. A possible solution to this problem may lie in combination of statistical energy analysis with deterministic modeling techniques (such as finite elements) applied to components, and/or component modal testing. If successful, these methods will offer an opportunity to greatly improve capabilities for prediction of vibration and structural acoustic responses of systems and structures. Prediction of mid-frequency behavior of a system by deterministic approaches alone is very expensive in terms of modeling effort and computation requirements. Full-structure testing requires costly setup effort and testing time, as well as the added possibility of limitations on quantity and quality of data. Modeling and/or testing of individual components greatly simplifies the process but does not provide information on the full system. By combining results from deterministic approaches on components with the statistical energy analysis approach for modeling of the full system, useful and more accurate predictions will be able to be obtained for the frequency response of systems and structures.

This is a new area of endeavor which will provide for a great advancement in the technical field of vibration and acoustics. The proposed program is one which will require carefully considered methods of research and development, and which will necessarily include strong foundation in theory, analysis methodologies, and experimentation.

A major purpose of the SBIR includes technological innovation by the small business and an associated increase in the commercial application of the technology. This is in addition to improved naval products and processes. To accomplish this, a three phase program is established, and each phase should be addressed in proposals.

PHASE I: Develop an improved SEA method for mid-frequency analysis involving deterministic computational approaches, and/or experimental procedures, which are applied to an example structure or system. The results must allow for determination of the scientific merit and feasibility of the prediction method and its technological approach. The program of research, including theory, methodology, analysis, results, and conclusions will be documented and discussed in a formal deliverable, as well as in appropriate peer-reviewed journal articles.

PHASE II: Apply the Phase I prediction method(s) to additional example structures for verification and confidence in the technology. The progress in work is also expected to lead to a well-defined deliverable product, procedure, or process for improved mid-frequency statistical energy modeling and analysis. Possible products include publication of fully documented technical procedures and approaches, and/or direct incorporation of techniques into commercially available products such as computer software.

PHASE III: Transition to direct Government (non-SBIR) applications and support or direct commercial application and private sector support. However, the resulting products and services must be able to be directly applied to vibration and acoustics problems in Naval ships and submarines and related structures, for further Naval support.

COMMERCIAL POTENTIAL: In addition to Naval applications, aircraft and aerospace systems have also been served by the SEA approach. More recently, SEA methods have been applied to vibration and acoustic problems in the automobile and truck industries. The problem of predictions in the mid-frequency regime have been a source of concern for all these application areas. Manufacturers of armored personnel vehicles and other equipment for the Army

and Marine Corps would also share in the benefits of the above noted technology advances. Presently there is a great lack of well-established modeling practices for the SEA approach. This is mostly due to the fact that it is a relatively new technology, but it also pertains to the matter of SEA not having been exposed to wide use and extensive development. Refinement of modeling procedures and improvement of accuracy will be eagerly accepted by modelers/analysts working with SEA in industry, and will allow for an important step in the effort to establish more standardized practice.

#### REFERENCES:

- 1. K.T. Brown, "Measurement of Modal Density: An Improved Technique for Use on Lightly Damped Structures," J. Sound Vib., Vol. 96 (1), 1984, pp. 127-132.
- 2. Lyon, R.H., and R.G. DeJong, Theory and Applications of Statistical Energy Analysis, Second Edition, Butterworth-Heinemann Publishing, Newton, Massachusetts, 1995.
- 3. Manning, J.E. "Calculations of Statistical Energy Analysis Parameters Using Finite Element and Boundary Element Models," Proceedings of International Congress on Recent Developments in Air and Structureborne Sound and Vibration, Auburn University, Auburn, Alabama, March, 1990.

#### N97-063 TITLE: Dielectric Mix Ratio Sensor

OBJECTIVE: Develop a dielectric sensor for in-line, real time, monitoring of the chemical mix ratio during manufacture of Advanced Special Hull Treatment materials.

DESCRIPTION: In the application of Advanced Special Hull Treatment on submarines, two chemical components are mixed in a certain ratio to obtain the desired polymer. The problem is to develop an in-line, real time dielectric sensor whose output can be correlated with the mix ratio of the two components.

PHASE I: Demonstrate that some combination of the dielectric constant and loss factor is correlated with mix ratio. Do this by comparing the dielectric properties of known mix ratios.

PHASE II: Optimize the frequency of operation, method of data reduction, and any requirements for sensor location and determine the sensitivity of the technique. The final outcome should be an instrument compatible with processing equipment and the supporting computer software and calibration curves.

PHASE III: This technique would transition directly into the Advanced Special Hull Treatment applied to submarines.

COMMERCIAL POTENTIAL: There is potential for use in the chemical industry for either Quality Control or process control in the manufacture of polymer parts.

REFERENCES: D. W. van Krevelen, Properties of Polymers, 3rd edition, Elsevier, New York, 1990.

### N97-065 TITLE: Improved Hull Form Patrol Combatant

OBJECTIVE: Develop the design for conversion of a PG hull to a Hydrofoil Small Waterplane Area Ship (HYSWAS) hull form, with high speed, and long range, large payload capability, and excellent motion characteristics.

DESCRIPTION: HYSWAS consists of an upper hull, connected by a single slenderstrut to a lower hull where buoyant lift is augmented by dynamic lift from a controllable foil system. It is desired to conduct a preliminary design for conversion of PG ship (from inactive fleet) and integrate it to a HYSWAS

underbody. Requirements are for continuous speed in SS-5 of about 40 kts, and range at 35 to 40 knots of 3,000 nautical miles or greater. Armament and combat system weight will be comparable to the PHM Class (Patrol Hydrofoil Missile Class) or heavier (30 L. Ton).

PHASE I: Develop a HYSWAS design concept and assess the feasibility to meet the described performance levels. Estimate performance characteristics through analysis or simulation, and provide ROM cost estimates and conceptual arrangements to retain/replace/relocate existing and new PG machinery as necessary.

PHASE II: Develop a preliminary HYSWAS Patrol Combatant design to meet the prescribed performance levels. Complete drawings suitable for detail design of the HYSWAS Patrol Combatant in Phase III. Provide a preliminary design package and specifications suitable for Phase III utilization based upon motion simulations to be conducted by the contractor and approved by the Government using the NSWC/CD ship motion program or equivalent.

PHASE III: Conduct a detail design for a HYSWAS Patrol Combatant and recover one or more PG hulls from inactive status for conversion to HYSWAS Patrol Combatant, in support of an ATD proposal effort focused on HYSWAS implementation.

COMMERCIAL POTENTIAL: HYSWAS design can be applied to large passenger ferries, small cargo carriers, and fast logistics deployment ships.

# N97-066 TITLE: Engineering Models of Reactive Munitions and Damage Effects

OBJECTIVE: Develop engineering models, based on first principles, and computer code that predict the damaging effects of reactive munitions on various types of missile and aircraft targets.

DESCRIPTION: The Navy is striving to develop more effective anti-air ordnance systems. Munitions that utilize reactive materials offer the potential of enhanced effectiveness over conventional munitions. Accordingly, the Navy is interested in developing such weapons and munitions. Analytical methodologies are required to evaluate new ordnance concepts, optimize weapon designs, and evaluate system effectiveness. Reactive munition concept testing is underway but is expensive and results cannot be extrapolated. The utility of hydrocodes to optimize designs and evaluate effectiveness is limited because of run-time and costs. Furthermore, present knowledge of the reaction chemistry is very limited. New concepts in modeling are needed to predict the behavior of reactive munitions and the associated target responses and damage in a fast-running, yet sufficiently accurate way.

PHASE I: Develop a simple lumped-parameter model that gives a better understanding of the important parameters involved in governing energy release rates and effects on targets. Model a simplified system involving one munition and one target. Determine the munition and target parameters that govern the outcome. Compare the model with key data as available. Conceptualize a more detailed model.

PHASE II: Expand the results of Phase I into more detailed models that include energy release rates, pressures, forces, stresses, and a range of realistic target geometries. Develop a fast running computer code that gives quick answers in lethality assessment and weapon development studies. Plan experiments to validate the models. Validate the code by comparison with experimental data and selected numerical simulations.

PHASE III: Improve and extend the model and implement it into lethality assessment and system effectiveness simulations used by the weapon development community.

COMMERCIAL POTENTIAL: This modeling capability could find potential dual use applications in the commercial sector in areas such as explosive forming of metals and pyrotechnique devices. The latter include air bags in automobiles, explosive release bolts, ejection seats and demolition industry.

# N97-067 TITLE: Low-Cost, High-Performance Propulsion Components for TMD Missiles

OBJECTIVE: Develop a low-cost fabrication technique for ceramic-matrix-composite tactical rocket nozzles and propulsion components.

DESCRIPTION: Costly and heavy rhenium-based alloys are projected to be primary construction materials for critical propulsion components in divert and attitude control systems (DACS) for Theater Missile Defense (TMD) concepts. It is believed that continuous fiber ceramic composites (CFCCs) could provide higher performance at lower cost and weight. A potential composite system includes carbon fiber reinforcement (for elevated temperature strength and thermal stress resistance) with a refractory, oxidation-resistant matrix (such as HfC, HfB2, or possibly HfN). At this time, such composites require lengthy processing times. A shorter time (and lower cost) fabrication approach is desired. The proposed fabrication cycle must allow high control of matrix composition, fiber/matrix interfaces, and processing stresses (fiber-matrix).

PHASE I: Identify a controllable, rapid, and low-cost processing/fabrication approach for a nozzle shell geometry, and identify critical technology issues required to demonstrate the approach. Fabricate simple geometry components, such as cylinders, and provide mechanical property characterization sufficient to affirm the fabrication approach. Perform other critical analytical predictions and/or experiments to provide high confidence of satisfactory demonstration of a representative component in phase II. The proposed fabrication approach should reflect a strong understanding of the material requirements (eg., thermal, chemical, mechanical) imposed by the rocket nozzle or propulsion environment. The phase I effort should also show how the fabrication approach is sufficiently flexible to tailor the material properties for the application.

PHASE II: Technologies required to demonstrate the fabrication/processing approach shall be developed in phase II and representative nozzle components shall be produced. A component demonstration plan shall be prepared which identifies a suitable demonstrator motor, identifies critical material properties, and fabricates/characterizes sufficient material to confirm the material capability for the demonstration. A component demonstration test shall be performed.

PHASE III: The developed CFCC material shall be qualified for the selected TMD/DACS propulsion component(s). The advanced material may potentially transition into all Navy (and Army) TMD missile concepts.

COMMERCIAL POTENTIAL: The developed material fabrication approach would have broad application to the manufacturing of low-cost, high-temperature structural materials. The technology could be applicable to advanced commercial gas turbine engines for aircraft or for power generation. In addition, the materials technology could significantly reduce the cost of advanced composites for satellite propulsion and earth-to-orbit vehicle applications.

#### REFERENCES:

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- 2. Kardell, M.P., et al., "Arc-Heater Ground Testing of Oxidation-Resistant Carbon-Carbon Materials," NSWC TR 87-32 (Feb 1987). (Avail DTIC)
- 3. Campbell, J.G., "Refractory Chamber Materials for N<sub>2</sub>O<sub>4</sub>/Amine Propellants," AFRPL-TR-73-31 (May 1973). (DTIC AD-762531)

# N97-068 TITLE: Thin, Lightweight, Broad Band Microwave Absorbing Material

OBJECTIVE: The objective of this effort is to create a lightweight, broad band microwave absorbing material that covers the X and Ku frequency bands and is thinner and lighter than the materials that are currently available on the open market. The absorber must be pliable and have the capability to adhere to metallic or composite surfaces. It must maintain good absorbing characteristics for high angles of incidence relative to the surface's normal and also perform well for all antenna polarization's relative to the absorber surface (perpendicular linear, parallel linear, elliptical, etc.). Finally, it must also have the capability to reduce surface waves.

DESCRIPTION: The effectiveness of Electronic Warfare Systems (EWS) and active electronic airborne decoys that simultaneously transmit and receive at the same frequency require some degree of antenna isolation. The type of microwave absorbing material required to isolate the antennas on these systems is constrained by several inherent properties. The absorber must be thin, and light weight so it does not impede the performance of the system being treated. The absorber must be pliable for applications around various edges. Since most EWS's and active decoy vehicles have both transmit and receive antennas in close vicinity of each other the absorber must maintain good absorbing characteristics across the band for large off normal angles of incidence for all types of antenna polarization. Most surfaces on EWS's and active decoy vehicles are conductive requiring the absorber to also have the capability to reduce surface waves.

PHASE I: Through the use of computer codes and empirical data determine the physical characteristics and design concepts of the microwave absorber backed by pertinent theoretical and analytical data. Provide the performance objectives of the material. Develop a Phase II plan that demonstrates the technical feasibility of the proposed design.

PHASE II: Using the chosen design from the trade-off analysis of Phase I, prototype material will be developed and tested to ensure it meets or exceeds all specifications spelled out in the Description. A demonstration of the concept will be provided with the prototype material.

PHASE III: The material will be implemented onto specific government furnished decoy models to be tested and evaluated in either a government or contractor furnished isolation chamber.

COMMERCIAL POTENTIAL: The largest commercial potential for this technology will be in the communications industry where unwanted noise or cross talk between antenna systems can be isolated to produce clearer and stronger signals. It also useful for commercial anechoic chambers.

#### N97-069 TITLE: Advanced Cable Connector Concents

OBJECTIVE: Provide efficient topside electrical/fiber optic cable connection while minimizing corrosion damage and crew maintenance. Reduce cost and acquisition lead time for cable connectors.

DESCRIPTION: Topside cable connection is a chronic problem from the perspective of corrosion control, protection against Electro-Magnetic Interference (EMI) and Electro-Magnetic Pulse (EMP), burdensome crew labor requirements, and high unit cost. Cable connectors must be weather resistant, provide grounding for EMI/EMP currents, provide stress relief for cables, and resist corrosion. Specification requirements for weather exposed cable connectors is for stainless steel materials. Historically, the high unit cost for stainless has forced the program managers for combat system equipment to resort to anodized aluminum. These rapidly corrode in marine environment unless costly and labor intensive weather barriers are applied. Conductive polymer/composite cable connections will alleviate this problem.

PHASE I: Develop the materials and geometry that will result in low cost, EMI/EMP resistant, corrosion resistant cable connectors or cable connector families. Develop cost model for anticipated production of connector families.

PHASE II: Construct test sets of connectors and conduct life expectancy tests in accelerated marine environment, and verify EMI/EMP requirements are satisfied. Perform a ship test of the product.

PHASE III: Initiate standardized inter-service application of the connector families. Verify that production unit cost models are accurate. Incorporate design in appropriate ship/combat system specifications. Prepare industrial processes for full scale production.

COMMERCIAL POTENTIAL: Weather resistant, low cost cable connections are applicable to a wide spectrum of industrial/commercial products. Among these are petro-chemical operations, maritime operations, space systems, robotic systems.

REFERENCES: Military Standard Mil-C- 24758.

## N97-070 TITLE: Distributed EMCON and Frequency Plan Performance Monitor

OBJECTIVE: Design and develop new techniques for implementing and analyzing the performance of ship and task force elements in adhering to the prescribed EMCON and frequency management plans.

DESCRIPTION: Current real time analysis tools do not adequately support the ship commander or task force Command and Control Warfare Commander (C2WC) in assessing the level of adherence to the currently prescribed EMCON and radar/communication frequency management plans. Because of the large dynamic complexities associated with distributed communications / combat systems, new advanced techniques and automated systems are required. These automated systems should provide some form of independent emissions monitoring as well as the capability to compare this feedback with the forward-fed information from the distributed network and make a recommendation as to how to eliminate observed violations.

PHASE I: Develop design information for an automated EMCON management system, and select and recommend modifications to current EMCON techniques that best meet PEO (TAD) requirements. Design information

shall include evaluation of current techniques for assessing the EMCON performance and frequency plan adherence in today's naval battle groups and new techniques for an automated EMCON Management system.

PHASE II: Build and deliver a brass-board (pre-prototype) system that demonstrates the feasibility of an automated EMCON management system in a simulated environment.

PHASE III: Build a full scale prototype automated EMCON management system, integrated with actual naval hardware and software (ISDS, CEC, etc.), capable of providing the ship's CO or BG C2WC with detailed performance and problem resolution information.

COMMERCIAL POTENTIAL: Advanced distributed communication systems are not unique to the DOD. This type of frequency management and emissions control tool would be directly transferable to industry and scientific institutions that use large distributed communication systems, including Television Stations, News services (mobile vans), and emergency communications and rescue systems.

# N97-071 TITLE: IR Countermeasures with Ultrabroadband Pulses

OBJECTIVE: Develop ultrabroadband sources of radiation in the 3-5 um and the 8-13 um windows.

DESCRIPTION: Cruise missiles pose a significant potential danger to the U.S. Navy. Ship defense against cruise missiles (and IR countermeasures in general) are therefore of particular interest to the Navy. Ultrabroadband radiation has the potential to enhance countermeasure capabilities through the generation of intense rediation over a broad spectrum covering the IR atmospheric transmission windows. Supercontinuum generation employing short laser pulses that develop self-phase modulation has been demonstrated in some experiments; for example Ref 1, the issues of interest here are pulse-to-pulse reproducibility, spatial uniformity, and repetition rate. For ship defense the wavelength range of interest lies in the atmospheric windows at 3-5 um or 8-13 um. Improvements are sought in time resolution and time sweep, as well as, efficiency of generation and directional properties.

PHASE I: Develop and report design information and design concepts for compact 3-5 um and 8-13 um ultrabroadband radiation sources, to function as a supercontinuum source of radiation for IR countermeasures. Issues to be addressed include efficiency and resolution.

PHASE II: Design and develop a brass-board model of a supercontinuum source of radiation for IR countermeasures based on the design concepts of Phase I. Conduct tests and operationally demonstrate IR countermeasures capabilities.

PHASE III: In partnership with industry, produce a prototype ship defense system employing ultrabroadband radiation to defend and protect own ship against cruise missiles.

COMMERCIAL POTENTIAL: Ultrabroadband radiation sources have a multitude of civilian applications, including active remote sensing for environmental monitoring and the detection and control of pollutants.

REFERENCES: R.L. Fork, C.V. Shank, C. Hirliman, R. Yen, and W.J. Tomlinson, Optics Letters 8, 1 (1983).

# N97-072 TITLE: Integrated Weapon Guidance

OBJECTIVE: Develop new methods for integrating the major functional components of guided weapon systems to improve overall effectiveness

DESCRIPTION: Traditionally, the major components of a guided missile such as the autopilot, guidance, fuze and warhead have been designed separately with only minor attempts at overall system integration. What integration is done usually involves trail and error adjustment of component parameters after the fact to arrive at some reasonable balance in the total design and a satisfactory level of performance. This is a costly and time-consuming process at best. In system flow diagrams, the guidance function is represented as an element wedged between the autopilot and seeker. In terms of total design optimization, a more integrated approach is desired. The guidance is the central decision and control function of the missile, and to maximize performance and effectiveness, it should be closely integrated with other functional areas of the missile involving sensors, data processing, control and damage mechanisms.

PHASE I: Develop methods for integrating the missile guidance and autopilot functions in a unified design approach. Include the use of blended control of non-collocated sensors and actuators, such as aerodynamic surfaces and jet-side thrusters. Show direct design integration between the multi-variable autopilot and advanced guidance laws. Demonstrate the feasibility of the integration method by simulating closed-loop guidance against highly agile targets.

PHASE II: Extend the work of Phase I to develop an integrated approach to design of the guidance/control and fuze/warhead subsystems. Optimize the interactions among the functional elements to achieve performance superior to that now available, including lighter weight. Using a detailed, nonlinear 6-DOF missile simulation, demonstrate the ability of the integrated weapon guidance to achieve direct hit accuracy on selected parts of the target body at favorable geometries. Address real time implementation of the algorithms in a missile borne computer.

PHASE III: Fully develop and transition flight-worthy integrated guidance designs to an Advanced Technology Demonstration (ATD) or a Pre-Planned Product Improvement of an existing weapon system such as the STANDARD Missile Block IV.

COMMERCIAL POTENTIAL: A unified system design methodology combined with new software tools would find use in a variety of commercial applications, including the aerospace and transportation industries. Applications involving multiple sensors and control effectors, managed by a central decision system, can achieve tightly regulated or controlled outputs.

# N97-073 TITLE: Low Cost Compact Phased Array Radar

OBJECTIVE: Develop a novel low-cost phased array radar to equip platforms heretofore un-equipped due to cost, size and weight constraints.

DESCRIPTION: New radar technologies will be applied to develop a low cost compact phased array radar. These technologies may include but are not restricted to: 1) Transmit Receive (TR) Elements; 2) Radiant type diode lenses; 3) ferro-electric element arrays; 4) optical beam forming techniques.

PHASE I: Develop Innovative architecture for a low cost compact phased array radar. The system must be able to generate a new beam every 0.1 micro seconds. Every beam must be randomly accessible from every other beam within 0.1 micro seconds. The beam's angular spread and side lobe characteristics must be competitive with current generation phased array radars. The beams must be isolated from each other to at least 100 dB. The size of the design must be within the following limits: 1) The phased array elements must be fully integrated with the antenna; 2) All components other than the TR element array and associated cabling must fit within one standard Navy 19 =AB" rack. The system must have 30 Km range or better. The signal must be of the quality to support MTI type processing. The radar must be able to detect both air targets and surface targets against clutter.

PhaseII: Produce demonstrator of the above system containing having a one dimensional array of 64 elements. Provide a limited design disclosure package and other documentation of the demonstrator.

PHASE III: Produce a 64 x 64 element prototype system suitable for further Navy testing. Include supporting documentation, such as a design disclosure package, operational and maintenance documents, etc.

COMMERCIAL POTENTIAL: Low cost highly effective radar for air traffic control, coastal & boarder control, drug interdiction and security & law enforcement.

#### N97-074 TITLE: Advanced Reactive Intermetallic Propellants for Dual Use

OBJECTIVE: Development of High Energy/Weight Ratio reactive Intermetallic Materials (RIMM) for various weapons and space system propulsion.

DESCRIPTION: High energy/weight propellants will allow the Navy to develop weapon systems with longer ranges, greater lethality, and greater reliability, and space systems with longer service lives, lower costs, and greater flexibility. This development will also allow commercial space systems to increase performance and economy.

PHASE I: Develop RIMM design information. Identify at least three materials / processes / mechanisms suitable for developing RIMM technology to the demonstration stage and the systems potentially suited for application

of the technology. Identify areas and techniques for retro-fitting RIMM technology to current systems, analyze the technology risks, and develop statements of work for Phases II and III. Deliver a final report describing the state of RIMM propellant technology as applied to propulsion mechanisms for guns, military and civilian missiles, and attitude control systems for space platforms.

PHASE II: Hardware implementation and testing of at least two of the materials / processes / mechanisms described in Phase I. At least one of these would be applicable to civilian space technology and both to naval weapons technology. Deliverables are to include a final report on performance advantages of the materials / processes / mechanisms over the current materials.

PHASE III: Navy funding -- Optimize the RIMM materials for cost, performance, safety, and producibility, and retrofit into current systems or place in emerging systems as applicable.

COMMERCIAL POTENTIAL: Commercial potential exists in the fields of air-independent propulsion and space vehicle launch/control.

REFERENCES: U.S. Patent # 5,010,804 (dated 4/30/91), "Launching Projectiles With Hydrogen Gas Generated From Titanium-Water Reactions"

N97-075 TITLE: Optical Delay Line Correlator

OBJECTIVE: Develop a fiber optic delay line correlator for application to radar.

DESCRIPTION: This system would sample and store the transmitted signal of a radar system. This signal would circulate though a fiber optical loop and be extracted periodically to be correlated against an incoming signal. The delay line might have the ability to amplify the stored signal to compensate for attenuation due to repeated tapping out of the signal. The delay line is in effect a very high fidelity memory in which the delayed signal becomes the reference signal for the radar echo.

PHASE I: Design optical delay line memory system and associated correlator. This system must optically encode an RF signal with minimal noise and distortion. It must store a signal for at least one millisecond. The system will have to deal with loss associated with tapping out the signal in a manner that minimizes noise. It must be able to correlate over the instantaneous input signal without ambiguity. The correlators might utilize but are not restricted to acousto-optic technology. They must work with minimal noise and signal distortion.

PHASE II: Build demonstrator of the system described in Phase I.

PHASE III: Transition to Naval radar program.

COMMERCIAL POTENTIAL: Improved radar for air traffic control, boarder control, drug interdiction.

N97-076 TITLE: High Resolution Atmospheric Data Retrieval

OBJECTIVE: Translate general atmospheric predictions and conditions (cold fronts, humidity, precipitation, barometric conditions, prevailing winds, etc) into small-scale high resolution conditions present in the scale of combat operations or flight deck operations. This will enable the modeling and simulation community to transfer atmospheric data from a live simulation for use with simultaneous virtual and constructive simulations.

DESCRIPTION: For high fidelity simulations it is imperative that the simulated environments are correlated with the live-play environments at a resolution sufficient enough to allow correlated environmental effects. The behavior of the natural environment is very difficult to describe and predict at the very small scale. Yet, this is the very resolution that equipment and personnel interact with the environment. The wind field in rugged terrain or around the superstructure of a ship hardly resembles even the highest resolution operational numerical weather models. Current methods used to build high resolution atmospheric databases primarily rely on conventional measurement techniques. Methods are needed that will allow visulation schemes in simulations to remain faithful to that which exists in the real world. This is to support the desire for live play simulations. This requires, for instance, that the clouds in the simulation and those in the real world be the same, not just statistically similar.

PHASE I: Develop the principles by which high resolution atmospheric data can be gathered remotely to support simulations incorporating live play.

PHASE II: Develop and validate, a prototype system that can extract near real-time atmospheric data for use in correlating atmospheric conditions to live simulations with the simulated environments in virtual and constructive simulations.

PHASE III: Develop an operational system to extract near real-time atmospheric data that can be used with civilian and military simulations.

COMMERCIAL POTENTIAL: This system could be used in any applications where the recording of actual atmospheric conditions at high resolution are required, but not readily available from other sources. The techniques developed here would supplement atmospheric observations at weather-sensitive locations.

#### REFERENCES:

- 1. DoD Directive 5000.59, "DoD Modeling and Simulation (M&S) Management, January 4,1994
- 2. Under Secretary of Defense for Acquisition, "DoD Modeling and Simulation (M&S) Master Plan," DoD 5000.59-P, October 1995

### N97-077 TITLE: Atmospheric Data Assimilation System

OBJECTIVE: To develop a data assimilation system which merges satellite data of a specific geophysical parameter (wind speed, temperature, ozone content, etc.), obtained from several satellite instruments, with a large range of horizontal and vertical resolutions in order to produce a gridded global data set.

DESCRIPTION: Many geophysical parameters of importance to both military and civilian scientific applications are now obtained with several instruments at a variety of horizontal and vertical resolutions. However, a general data assimilation system, which combines all this input data in order to produce an instrument independent global data set, does not currently exist. Using recent advances in retrieval and information content theory, this problem can be cast as a retrieval problem in which the retrieved parameter is an estimate of the global distribution of a geophysical parameter, consistent with both the input measurements (in which the resolutions and errors are taken into account) and other related information about the state of the atmosphere. This system could be used as both a data assimilation tool for research and operational purposes, and a tool for developing measurement strategy for future missions.

PHASE I: Develop the framework for casting this particular problem as a retrieval problem. Test the algorithms developed in this effort by application to simple simulated data sets.

PHASE II: Extend the retrieval algorithms to handle real data and include treatment of retrieval errors. Test the algorithms by application to real measurements. Apply information content theory to the retrieval to determine the horizontal, vertical, and temporal resolution of the retrieved global data products. Apply the software package to the Ozone and Aerosol Monitor (OAM) series of solar occultation sensors being flown by the Navy. Produce a software package sufficiently robust to be used operationally with real data sets.

PHASE III: Generalize the software package to be used for any measurement parameter, and make it sufficiently user friendly to be readily used by other research and operational groups as both a data analysis system and an experiment planning tool.

COMMERCIAL POTENTIAL: A robust global data assimilation system would have applications in many areas of space-based remote sensing, in both the defense and civilian arenas. With the large increase in satellite systems, both operational and research oriented, devoted to measuring a variety of important geophysical parameters during the past 10 to 20 years, there now exist significant numbers of independent data sets. This data frequently overlaps in time and space, and contains the same geophysical parameters. The ability to assimilate them in a rigorous, quantitative way into global data sets would create new understanding in scientific pursuits, while satisfying operational accuracy and utility requirements. There is also an obvious potential for application of this algorithm in both mission planning, as well as subsequent data reduction and analysis, for large, multi-platform systems such as the planned converged NPOESS system, and for commercial space-based remote sensing satellites which generate global imaging data.

REFERENCES: Rodgers, C.J., "Characterization and error analysis of profiles retrieved from remote sounding measurements", J. Geophys. Res., 95, 5587-5595, 1990.

# N97-078 TITLE: Advanced Signal Processing Applied to Electronic Warfare (EW)

OBJECTIVE: Investigate the feasibility and benefits of using advanced signal processing techniques in the EW areas of EW Support (ES) and Active Electronic Attack AEA. In ES the goal will be to determine the real improvements and principle limitations in the detection, classification, and identification of RF signals by the implementation advanced signal processing techniques. In AEA the aim will be to determine the practicality of tailoring active EA emissions to maximize AEA effectiveness.

DESCRIPTION: Advanced signal processing is the application of the more recently discovered techniques to exploiting of the mathematical relationships between measurable physical events in the electromagnetic spectrum. These techniques have been used effectively in other areas, particularly in the acoustic and communication fields. The task will be to determine weather or not these processing techniques or algorithms can be effectively and practically utilized for EW. The approach will be straightforward. A list on candidate techniques will be tested using simulated video output of a typical EW receiver, e.g., the AN/SLQ-32. These simulated signals will include normal useable formats, e.g., a regular pulse train with good signal-to-noise ratio, as well as normally unusable formats such as noise-like signals with low signal-to-noise ratios, overlapping signals, and signals which represent particular environmentally generated conditions such as long and short-path-difference multipath.

There are a number existing onboard AEA techniques that range from the generic, such as wide-band noise, to the threat-specific, i.e. varying a transmitted modulation to match that used in the guidance and control logic of the threat. However, all are based on the premise that by providing the threat radar (fire control or seeker ) with another signal, the threat radar will either see and/or lock on to this signal rather that the actual target return, or behave in an erratic way. The job of the radar designer is to give his system the ability to distinguish between the two; the job of the AEA designer is to make the generated signal resist such discrimination. The application of signal processing to AE could begin with the identification of differences in the jammer's signal and that of the target's return. The problem with this approach is that even if the generated signal can be made to look exactly like the target return, this does not guarantee that the radar will always accept it instead of the return. And even if it did, how would it lead the radar (seeker) away from the target? The approach that should be taken is to enhance the procedure that is already in use, which is to stimulate the victim receiver with various waveforms to get the masking or brake-lock that is desired. What is proposed here is that the repertoire of waveforms be extended to those that have more subtle variations, i.e., the use of non-stationary, non-gaussian noise or signal with tailored high-order statistical properties. For example, a signal which contains echoes or multipath will also have a periodic cepstrum (see reference 1) component related to the time delay of the echoes. The manipulation of this component in a AEA waveform may generate false targets which may be very resistant to echo cancellation techniques.

The ES results will be evaluated using two principal criteria: (1) That the output provide significantly useful information about the signal, (2) that these outputs be obtained in a tactically useful time frame using technology projected to be available in the year 2000 time period. The AEA results would be evaluated by simulation on available receiver and missile models. A plan to incorporate the useful techniques into the Advanced Integrated Electronic Warfare System (AIEWS) Program would then be developed.

PHASE I: Develop AEA design and process information, including a list of candidate techniques, ordered with respect to potential usefulness. Each process will be described in detail, including the limits of applicability, e.g., "will only work if noise is gaussian". For the ES techniques the amount and type of computations required to process a given amount of data must also be listed. For example, given N data points, a particular technique may take N^2 multiplies and N additions to get a result. The information content of the expected output must, of course, be described. Similarly, the requirement for the AEA technique must also be given, e.g., "must be implemented with Master Oscillator Power Amplifier".

PHASE II: Examine, test, evaluate the Phase I processes to identify the useful processes. Conduct extensive modeling; simulation, and where available use real, data. Perform field testing as necessary. A commercially available signal processor for the ES tests would very likely be necessary for the Phase II effort; AEA hardware would not. Delivered items shall include (but are not limited to) algorithms for each useful process, and the process test conditions, procedures, and results.

PHASE III: Integrate the selected processes into the AIEWS Program.

COMMERCIAL POTENTIAL: The information generated by this program would give new insight into the behavior of receiving systems to complex data input streams; input streams that have controllable discriminants that are not readily observable. These kinds of inputs may have the potential of enhancing the performance of commercial communication, control, and navigational systems.

#### REFERENCES:

- (1) "Higher-Order Spectra Analysis" Chrysostomos L. Nikias, Athina P. Petropulu, PTR Prentice Hall, 1993.
- (2) "Acousto-Optical Processing for the AN/SLQ-32", NSWCDD TR-95/173.
- (3) "Improving The DF Accuracy and Sensitivity of the AN/SLQ-32 by Using DSP with Application for LPI Detection and Interference Rejection," NSWC TR 90-293.

N97-079 TITLE: Advanced Signal Identification (ID) Device

OBJECTIVE: Develop a state-of-the-art emitter identifier.

DESCRIPTION: Electronic Warfare (EW) Systems capable of Specific Emitter Identification (SEI) currently rely upon the standard Electronic Warfare discriminants of Pulse Repitition Interval (PRI), Angle of Arrival (AOA), and pulse width (PW). An additional discriminant will soon be available. The Naval Surface Warfare Center, Dahlgren Division (NSWCDD) is constructing a prototype Advanced Signal Waveform Classifier, ASWC, for the measurement, identification, and classification of received radar signals. This device, to be completed in 4th Quarter 1997, is based on a state-of-the-art acousto-optic (AO) spectrum analyzer (acting as a channelized receiver) and provides 1-MHZ frequency resolution as well as the Frequency Modulation On Pulse (FMOP). This new discriminant (FMOP) will be added to the set of standard signal parameters; ie., PRI, Angle of Arrival (AOA), pulse width (PW), from a standard EW Support (ES) receiver. An ES receiver provides the standard discriminants, and the new AO analyzer provides the new FMOP discriminant. Further, improved ES technology exists to obtain much more precise measurements of the standard discriminants; possibly precise enough to perform SEI through a neural network in combination with the FMOP discriminant. It is desired to capitalize upon a combination of the new and standard EW discriminant set and to develop a new state-of-art Specific Emitter Identifier, preferably based upon a neural network, that will perform the parameter association and emitter classification necessary to obtrain an ID. In short, we desire a system combining the AO spectrum analyzer, an ES receiver, and a neural network for purposes of Specific Emitter Identification.

Phase I: Develop a Neural Network to perform the integration of the AO system with the Time-of-arrival technology (standard discriminants), derived from either a standard or an improved ES receiver.

Phase II: Construct and deliver prototype units comprising an SEI device for test and evaluation in laboratory and field environments. Complete integration with a current EW system, eg, the Advanced Integrated Electronic Warfare System, AIEWS, is not part of the Phase II effort.

Phase III: Perform Integration with Advanced Integrated Electronic Warfare System, AIEWS.

COMMERCIAL POTENTIAL: This Topic proposes development of a 'passive transponder', an advanced signal classifier applicable to civil aviation, commercial shipping, law enforcement, and military operations both open and covert. By utilizing advanced processing algorithms and acousto optical hardware, signals input from any RF and video signal source (eg, radar receiver) will be accepted. The AN/SLQ-32 or its future replacement, AIEWS, are specific military signal sources whose functionality would benefit if such a device were to be integrated with these systems. Civil/commercial aviation will likelwise be able to identify specific emitters and alerted to the presence of other aircraft, ground radars, and airborne threats. The device is a passive transponder, capable of classifying emitting platforms that transmit false, incorrect or no Transponder Codes. Transponders are now required on all commercial aviation and most commercial shipping, and can be incorrectly operated or silenced deliberately. This Topic proposes a passive Transponder not subject to such practices. (Remember that the 747 was shot down by USS Vincennes because it squawked a Transponder code that was reserved by the Iranian Air Force.)

REFERENCE: "Acousto-Optical Processing for the AN/SLQ-32", NSWCDD/TR 95/173

### N97-080 TITLE: Multi-Resolution Feature Imager

OBJECTIVE: Develop a novel optical imaging system that produces a "brain-like" representation of image features over multiple spatial scales.

DESCRIPTION: A major misconception is that the eye is equivalent to a camera. The eye is much more than a camera, it is a sophisticated feature encoder. The power of biological vision

systems lies in how they encode features over multiple spatial scales. This representation is referred to in some fields as the "neural image"[1]. Recently, Multi-Resolution Analysis (MRA)

Techniques such as the Wavelet Transform (WT) have revolutionized the way images are represented for pattern recognition applications. Newer types of wavelet transforms represent edge features over multiple scales [2]. These approaches have a profound underlying similarity to biological vision systems. Wavelet transforms require digital electronics for implementation. Though fast, for high data rate imaging systems, digital electronics may not have sufficient speed. It should be possible to integrate the imaging system and MRA processing so that the immediate output of the imager is in the MRA representation. Already there has been outstanding work in combining imaging and eye-like processing known as the "silicon retina"[3]. This topic would generalize this device to a Multi-scale feature encoder.

PHASE I: Develop design for a real time imaging system that outputs a MRA feature space representation of an image. This device must be able to represent salient features of an image over multiple spatial scales. Associated with the imager should be an algorithm for performing pattern recognition on the MRA feature space representation of the imagery.

PHASE II: Hardware implementation of the above system.

PHASE III: Transition above system to a weapons program in support of Automatic Target Recognition (ATR) functions.

COMMERCIAL POTENTIAL: Real time pattern recognition systems would have application to law enforcement and security, e.g., aspect independent face recognition systems. Another application area might be automatic recognition of motor vehicles for traffic monitoring & automotive safety systems. Industrial applications would include automatic pick-and-place machinery that deals with complex objects in random orientations.

# **REFERENCES:**

- [1] B. Wandell, Foundations of Vision, Sinauer Associates Inc., Sunderland, MA, 1996.
- [2] J. Garcia & H. Szu, "Chords in wavelet projection transform space applied to aspect invariant pattern recognition, SPIE Vol. 2762, Wavelet Applications III, 1996.
- [3] M. Maholwald & C. Mead, "The Silicon Retina", Scientific American, May 1991, pp. 76-82.

## N97-081 TITLE: Photonic Crystals for Laser Applications

OBJECTIVE: Development of Photonic Crystals for low-cost/high energy efficiency lasers.

DESCRIPTION: Lasers have been used in industry for medical applications such as eye and organ surgery as well as plastic surgery. They are also used extensively in the telecommunications industry. Furthermore, current military applications of lasers include weapon guidance systems. Future applications of high energy density output lasers include protective systems for Navy ships for destroying hostile enemy equipment (i.e., missiles, aircraft), and secure line of sight communications. The output of such high energy density lasers can be more than 10 kiloJoules per square centimeter (10kJ/cm²). Such systems could overcome the limitations of (and could replace or be used in conjunction with) the PHALANX systems currently used to defend Naval vessels from incoming missiles.

Theoretical studies have indicated that the most energy efficient laser crystals yielding the highest energy density outputs are photonic crystals. However, until recently, the only photonic crystals that were capable of being produced were severely limited in thickness, having been produced by manufacturing methods employing the use of colloidal suspensions. Recently, however, large three-dimensional photonic crystals were produced using the Navyowned and government-licensed Electroset Technology. Production of these large photonic crystals has been

determined to be extremely low in cost. This effort will use this low cost manufacturing process to produce photonic crystals for use in all of the aforementioned applications, including the high energy density output lasers for weapons systems.

PHASE I: Produce large three-dimensional photonic crystals and test and evaluate them for their optical properties to determine appropriate photonic band structure. Provide a final report describing the production of the photonic crystals together with the investigated and evaluated optical properties. Verify the optical properties necessary for commercialization.

PHASE II: Adapt the optical properties of the photonic crystals for use in a laser system. Construct and test this laser system and characterize its capabilities for use in both military and commercial applications.

PHASE III: Navy funding -- Optimize the laser systems for performance, cost, and producibility and adapt it for use on the SC21 to replace less efficient and more costly laser systems used in Navy communication and weapon systems. Adapt the laser system to replace (or, at the very least, to be used in conjunction with) the shipboard defense PHALANX system.

COMMERCIAL POTENTIAL: Commercial potential exists in the telecommunications industry (fiber optics), the CD industry, the medical equipment industry (diagnostic and surgical equipment), in the survey and ranging equipment industry, and in the scientific equipment industry.

#### REFERENCES:

Bulletin of the American Physical Society, vol. 41, no. 1, p. 191, March 1996; <u>Three-Dimensional Photonic Crystals Produced by Electroset Technology</u>; X. Wu, X. Zhang, R. Tao, and R. P. Reitz, Journal of the Optical Society of America (B), vol. 10, no. 2, Feb. 1993, <u>Photonic Band Gap and Localization</u>; editor C. M. Soukoulis, Plenum Press, NY, 1993

U.S. Patent # 5,190,624 Electrorheological Fluid Chemical Processing

U.S. Patent Pending Navy Case #75,833 Programmable Electroset Materials and Processes

N97-082 TITLE: Semi-Active or Active Highly Accurate Homing and Robust Tracking System for Agile Missile Guidance

OBJECTIVE: To develop agile and robust missile tracking systems, guidance filters and guidance/control laws to track the missile-target line-of-sight (LOS) in highly dynamic and stressing intercept engagements. To develop real-time moving target recognition and identification via template generation.

DESCRIPTION: Future missiles will fly in operational flight regions in which current missiles have never been exposed. Depending on the mission and tactical requirements, it is expected that guidance commands responding to highly dynamic line-of-sight (LOS) geometries may require a missile to perform very rapid, high angle-of-attack (alpha), high-g maneuvers in order to intercept the threat. As a result, large LOS error signals can arise, resulting in excessive guidance commands that saturate the actuators and control surfaces. The problem gets even more severe when environmental disturbances and sensor noises influence the system. Existing tracking and guidance systems often produce unsatisfactory

dynamic responses due to misalignments of the sensors, noisy tack information and inadequate LOS processing and tracking performance. Another shortfall is the task of target search, acquisition, identification, and lock-on operations in a noisy environment (i.e., jamming).

Modem robust control design techniques such as H-Infinity, Mu-Synthesis and Multiplier methods have proven to be the most efficient design tools to handle systems with various external or internal dynamic uncertainties. These techniques can allow multi-channel guidance and control systems to meet the missile design requirements. External disturbances, sensor noises, and massive gain-scheduling can no longer threaten system stability and performance. These methods have been applied to supermaneuverable fighter aircraft flight control and flight testing is currently underway. To minimize the LOS tracking error and near misses or errors in closing operations, a target can be identified in real-time through a three-dimensional pattern matching technique. The missile can then track and lock-on the moving object more effectively.

PHASE I: The phase I effort will develop concepts for missile guidance laws and target filtering algorithms and analyze the performance payoff achievable. Concepts will include guidance law and target filtering algorithms that

may include the following: (a) using target recognition to tune guidance laws and target filters based on a defined target set, (b) using target measurements to detect target maneuvers and adjust guidance law response, and (c) using target measurements to achieve guidance hits at preferred target components. Analysis will be conducted to define seeker range and doppler resolution required to robustly identify target type and to detect target maneuvers and also determine the time window available for data collection. Since real time processing is an absolute requirement for eventual use of the algorithms, a survey of applicable RF and IR processing techniques will be conducted and analyzed relative to guidance requirements and signal processing hardware requirements. The study will then down select among the algorithms based on computational and seeker burdens. The resulting algorithms will then be analyzed and customized to the guidance application. A simulation of the guidance process will be developed and used to analyze resulting performance and robustness to sensor measurement and alignment errors, target maneuver profiles, target geometry and sensitivity to processing throughput.

PHASE II: In Phase II, real time implementations of the guidance/filtering algorithms will be developed and demonstrated via hardware-in-the loop simulation, using a separate computer (not form fit to the guidance unit) to process target data. In Phase II, the demonstrations will involve only a limited number of target types and will demonstrate the capability to achieve actual hits at critical locations on the target body.

PHASE III: In Phase III, flight-ready algorithms will be demonstrated via hardware-in-the loop simulation and/or flight test demonstration. Algorithm performance will be assessed using a flight worthy form factored guidance and control computer. Targets to be modeled and simulated will cover the complete range of expected threat types, and the demonstration will include recognition of the target type from among the complete spectrum of targets.

# COMMERCIAL POTENTIAL: Commercial applications of these approaches would benefit

Ythe aerospace and transportation industries. In particular, these modern robust control techniques could be applied to aircraft, satellites, missiles, launch vehicles, intelligent transportation vehicles and systems, and other tracking systems.

# N97-084 TITLE: Towed Array Technology Communication Link Bandwidth Expansion

OBJECTIVE: Develop an increased bandwidth for the existing uplink and downlink communication/connection path between a towed array and the tow ship.

Description The acoustic towed line arrays of interest are towed between one and two kilometers behind the ship. The existing communication bandwidth between the tow ship and towed array is presently limited by a single coaxial cable link to 6 Mbits/sec to 12 Mbits/sec. The objective is to provide an uplink and downlink bandwidth of 25.6 Mbits/sec with a goal of 155 Mbits/sec over the existing single coaxial cable and slip ring connection path presently deployed on Navy submarine and surface ships. (Offerors should not propose optical cables because of the expense of development and deployment of new optical tow cables and slip rings on existing ships.) Maximum use of commercial communication technologies such as Digital Subscriber Line (xDSL) technology development and telecommunication bandwidth expansion is highly desired. Most of the towed arrays for demonstrating the required technology are 1.5 or 3.0 inches outside diameter. The towed array DC power is usually sent over the same coaxial cable link used for communication. It is essential to draw power from the existing array power source. The towed array end of the communication link has to survive 2500 psi pressure exposure. Affordability and covertness of the proposed approach are highly desirable.

PHASE I: Develop and define and describe the concept for a prototype high bandwidth communication link. Develop a preliminary subsystem design which will demonstrate the proposed subsystem. For the Phase I option, provide a laboratory demonstration of the technology.

PHASE II: Design, fabricate and demonstrate a complete high bandwidth communication link prototype subsystem compatible with existing Navy acoustic towed line array(s) to be selected by the Government.

PHASE III: Fabricate, test, and evaluate additional high bandwidth communication link subsystems, and provide these subsystems under a towed array common telemetry program.

COMMERCIAL POTENTIAL: Commercial potential includes acoustic towed arrays used in oceanographic and oil exploration. The technology may be applicable to telecommunications. BISDN, Coaxial Cable upgrades, and related developments are potential markets for this technology.

#### N97-085 TITLE: Low Power Long Wave Infrared Laser Sources

OBJECTIVE: Develop technology for a low - medium power, pulsed or continuous wave laser that operates in the 7.5 - 9 micron spectral band.

DESCRIPTION: Develop a new solid state and/or gas laser sources to generate high repetition rate (> 1 0 kHz) or cw output powers of 5 - 1 0 watts on laser lines that operate in the 7.5 - 9 micron spectral band. The laser lines shall be tunable and have good atmospheric transmission. The laser mode quality shall not exceed 2 times diffraction limited.

Phase 1: Explore concepts from analytical and experimental perspectives to determine the feasibility of a pulsed or cw LWIR laser meeting the average power, wavelength and beam quality requirements. The study shall address the design and performance of a system to be fabricated in Phase II as well as power scaling issues in achieving 5-10 w/line output power.

PHASE II: Design, fabricate, test, and deliver a laboratory brassboard, pulsed or cw, 5-10w, LWIR laser system. The laser shall also meet wavelength and beam quality requirements.

PHASE III: Transition technology to develop compact and ruggedized systems for military and commercial applications.

COMMERCIAL POTENTIAL: Refrigerant leakage detection and air pollution monitoring.

#### REFERENCES:

- (1) 2ND NATO/IRIS Joint Symposium, 1996.
- (2) IRIS IRCM Symposium, 1996.

# N97-086 TITLE: <u>Technology Insertion for Acoustic Countermeasures</u>

OBJECTIVE: Develop innovative countermeasure capability(s) for insertion into current submarine countermeasures (CMS)

DESCRIPTION: The current generation of submarine countermeasures consists of the ADC Mk 2 Mod 0/1, the ADC Mk 3, and the ADC Mk 4. Some of these devices were designed to counter targeting by a threat acoustic sonar. Others were designed to defeat a threat torpedo. Additionally, there are other devices used for training that are deployed from countermeasure launchers. The original designs for each of these devices assumed they were truly "throw away." Consequently, the designs do not include any provision for refurbishment to extend shelf life of a device that is Not Ready for Issue (NRI). Moreover, as threats become more sophisticated, maintaining the effectiveness of the countermeasures will require capability enhancement or redesign. Additionally, component obsolescence becomes a supportability and producibility issue.

PHASE I: Develop a modular architecture that facilitates capability insertion and/or resolution of device obsolescence. Breadboard where appropriate to demonstrate feasibility.

PHASE II: Fabricate, test and demonstrate brassboard countermeasure modules and countermeasures modifications to incorporate the architecture of Phase I.

PHASE III: Produce prototype model countermeasures embodying the modular architecture and modifications of Phases I and II. Test and evaluate and qualify the prototypes for full scale production in conjunction with prime (original equipment manufacturer) contractor.

COMMERCIAL POTENTIAL: The technologies developed under this effort could be adapted to provide a variety of capabilities applicable to the disciplines of ocean exploration, marine biology and oil exploration.

# N97-087 TITLE: Covert Underwater Communications

OBJECTIVE: Develop Adaptive Channel Characterization algorithms to support very low frequency (VLF) covert acoustic communications between submarines and other platforms.

DESCRIPTION: Application of Adaptive Channel Characterization algorithms to processing of acoustic communication signals offers performance gains in underwater communications over previous designs. An Advanced Technology Demonstration (ATD) is in progress to demonstrate these techniques using medium and high audio frequencies. While useful for many applications, these modes are not acoustically covert. Certain tactical scenarios require covert signaling. Past experience indicates that, only by utilizing extremely low frequencies for communication, can absolute covertness be achieved. Use of such frequencies has the following advantages. Extremely long towed arrays or SOSUS-like receivers detect such signals due to the extremely long wavelengths. Such signals are within significant self-noise regions of typical intercept units. There is very low propagation loss; therefore, relatively long ranges are achievable with existing transmitting sources to the appropriately equipped receivers.

PHASE I: Determine the propagation characteristics of the VLF acoustic (sub-audio) region that are critical to covert VLF communications. Develop a simulated VLF acoustic propagation process, and determine the optimum propagation conditions. Demonstrate feasibility of the concept by inserting candidate VLF communication signal formats through the model.

PHASE II: Develop optimized real-time adaptive channel characterization algorithms for VLF covert communications. Deliver laboratory tested and evaluated realtime algorithms for initial at sea testing and analysis by the 'Advanced Technology Acoustic Communications' ATD Program aboard a submerged submarine.

Phase III. Develop final algorithms including self initialization and tracking for turn-key inclusion into the 'Advanced Technology Acoustic Communications' ATD program.

COMMERCIAL POTENTIAL: Applicable to needs wherever very long range (>10 NMI) remote underwater is required.

#### REFERENCES:

- 1. Stojanovic, M., Catipovic, J., and Proakis, J.; "Phase Coherent Communications for Underwater Channels", IEEE Journal of Oceanic Engineering, January 1993
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# N97-088 TITLE: High-Frequency Brushless Motor Technology

OBJECTIVE: Develop high frequency brushless motor technologies for application in Navy designed and maintained underwater systems.

DESCRIPTION: The Navy uses high frequency motors in a variety of systems including lightweight torpedoes, heavyweight torpedoes, Unmanned Underwater Vehicles (UUV), and surface and submerged combatant platforms. In many cases, the motors that are in service were designed prior to the development of efficient brushless motor technologies. Applications of high-frequency motors include the actuator assembly on Navy lightweight torpedoes, attitude positioning impulsors on UUVs, and, in general, applications aboard surface and submerged platforms. Such applications are suitable for commercially available brushless high frequency motor technologies with their potential: to provide additional supply sources; to improve system efficiency and performance at low cost; to provide electrical efficiency in power-use-critical and battery systems; and to operate quietly. Commercial motors would be required to meet the Navy environmental and dimensional requirements for any given application. Proposals should show offeror's knowledge of and intention to design for specific application(s) rather than simply describing the potentials of the offeror's technology.

PHASE I: For specific Navy application(s), design to operational requirements, develop, and demonstrate proof of concept hardware, taking into account such factors as system power requirements, noise, gearing, activation timing, overall accuracy, short and long term cost effectiveness (affordability).

PHASE II: Fabricate and test (bench level and in water or in service) prototype fully integrated high frequency brushless motor system. Do so with a sufficient number to verify size and performance characteristics.

PHASE III: Fully transition prototype designs into production. Scheduling of actual production will depend on the specific application(s) worked under Phases I and II. Specific influences could include: existing inventory of spares, funding for and priority of system retrofits.

COMMERCIAL POTENTIAL: Development of brushless motor technologies for Navy applications will broaden the range of usable non military applications. Advances in the special materials and magnetics technologies required to manufacture efficient brushless motors will result in more energy efficient motors and allow the commercial industry to conduct further miniaturization efforts on present motor designs.

N97-089 TITLE: Submarine-Based System for Detecting Ocean-Penetrating Laser Radar

OBJECTIVE: Develop a submarine-based advanced warning system against airborne laser radar

DESCRIPTION: Ocean-penetrating laser radars are being developed to map coastal water bottoms in littoral areas. Such laser radar systems employ pulsed lasers and sensitive receivers that exploit the propagation properties of seawater by operating in the blue-green wavelength transmittance window. Such laser radars could, in principle, be refined to detect submarines operating in these environments. The Navy has a need to recognize the operation of such laser radar systems and provide situation alerts to the submarine commander, and to detect the presence of such systems at maximum possible range consistent with a low false alarm rate. The objective of the program is to develop a submarine-based sensor to provide these functions.

PHASE I: Determine the limits, from a submerged submarine, for detecting the operation and signature of an airborne ocean-penetrating laser radar. Predict the performance dependence implied by these approaches and generate a preliminary design of a submarine-based threat warning system.

PHASE II: Design and develop a (brass board) prototype sensor system (to include hardware and software necessary for data collection, analysis, display, and interfaces), and provide for submarine installation, test and demonstration of this system to validate sensor performance. Sufficient on-board real time processing will be performed to ensure that good data is being collected and to support the functioning of the system.

PHASE III: The Phase III program will develop and test an operational sensor.

COMMERCIAL POTENTIAL: The research and development efforts needed to quantify the optical propagation characteristics of light through the atmosphere, the air-water interface, and the water column are important for understanding ocean-penetrating laser radars, optical communication systems, and sensors that exploit the blue-green optical transmission channel. Two-way optical communication between submerged and atmospheric terminals, the latter including aircraft and surface ships, is one application. Navy and commercial divers could potentially find their way back to surface support vessels using optical communication systems developed based on an understanding of this propagation path.

N97-090 TITLE: Full Band Acoustic Localization Processing

OBJECTIVE: Develop a capability for automated localization and tracking of multiple wideband acoustic signals. (intentional and unintentional)

DESCRIPTION: Develop signal processing algorithms that provide multi-track and localization capabilities for extended-frequency man-made acoustic emissions and support operations in shallow and littoral waters. The ability to further exploit detection events within the limitations of the platform profile is required for improved tactical effectiveness.

PHASE I: Develop, describe, and implement automated track/localization algorithms for application to an acoustic intercept system. Achieve proof-of-concept within the constraints of platform resources and operational environments.

PHASE II: Complete and test a full prototype implementation of the Phase I algorithms for at sea demonstration and evaluation. Demonstrate feasibility via a rapid prototype system for the host platform and process Navy provided tactical data.

PHASE III: fabricate and deliver additional systems for test and integration into existing US Navy platforms.

COMMERCIAL POTENTIAL: Surveying, mining, oil exploration and marine biological research.

## N97-091 TITLE: <u>Towed Array Localization</u>

OBJECTIVE: Develop an acoustic towed array subsystem to precisely determine the location, distance and direction of a towed line array relative to the array tow ship.

DESCRIPTION: Acoustic towed line array position relative to the tow ship is essential to allow target range determination by using both the tow ship's hull mounted acoustic array and the tow ship's own acoustic towed line array. Existing towed array sensors provide precise heading, depth and pitch of a towed line array, but towed location relative to a towed array and own ship is not known with sufficient precision to implement an accurate range determination by triangulation with the ship's sonar and the towed array sonar sensors. The approximately three inch diameter towed array technology, employed by many submarines and surface ships, would be the likely target for demonstrating the SBIR technology. Such arrays are towed up to two kilometers behind the tow ship. Affordability is a significant issue. Consequently, localization techniques which are easily backfit into existing towed array assets are more desirable than techniques which require extensive modification of existing assets and/or significant shipboard modifications. Moreover, sharing power and telemetry with an existing array is highly desirable. Covertness of the localization technology is also highly desirable.

PHASE I: Develop sufficient concept definition and description to demonstrate the accuracy of the localization subsystem. Develop a preliminary subsystem design which will demonstrate feasibility of the proposed subsystem.

PHASE II: Design, fabricate, and demonstrate prototype subsystem.

PHASE III: Transition into existing submarine and/or surface ship towed arrays.

COMMERCIAL POTENTIAL: Commercial potential includes activities where a tow ship desires to accurately know the location of the something being towed--for example, ocean mapping and underwater inspection.

## N97-092 TITLE: Fiber Ontic Measurement of Towed Array Shape

OBJECTIVE: Measure towed array shape using optical fibers and optical sensors.

DESCRIPTION: Measuring towed array shape by use of optical fibers and sensors has the potential of significantly improving the accuracy of the estimation. This topic involves selecting an optical fiber and sensor method for measuring array shape and developing the technology to make the implemented method practical and affordable.

PHASE I: Develop proposed approach for measuring array shape and conduct breadboard tests to establish rms shape error. In an array hose at lest 100 feet long, conduct tension and simulated handling tests to demonstrate survivability of fibers and sensors.

PHASE II: Develop fabrication process, fabricate a prototype array, test at sea.

PHASE III: Transition to fleet towed array system(s).

COMMERCIAL POTENTIAL: The same technology, once developed, can be applied to towed arrays used for oil exploration.

# N97-093 TITLE: Doped PMN-PT Single Crystals

OBJECTIVE: Develop and scale up process(es) for manufacturing single crystals of doped lead magnesium niobatelead titanate (PMN-PT) for use in transducers.

DESCRIPTION: Lead magnesium niobate-lead titanate (PMN-PT) doped with lanthanum or barium is an attractive transducer material for a variety of reasons, including its very high energy density and its capacity to undergo large electrostrictive strains. The main problem with doped compositions of PMN-PT is that the currently achievable coupling coefficient is less than optimal. Recent research suggests that the reason for the lower coupling coefficient is linked to microstructural details in the polycrystalline PMN-PT. One way to circumvent the problems of the polycrystalline microstructure and to realize improved coupling coefficients is to use single crystals. However, while

the technology for growing a wide variety of single crystal oxide ceramics exists, the technology for fabricating doped PMN-PT single crystals has not yet been developed.

PHASE I: Develop a process for fabricating electrostrictive single crystals of the doped lead magnesium niobate-lead titanate (PMN-PT). The developed process must be amenable to scale up for producing 1) large quantities of crystals and 2) crystals large enough to use in Navy transducer applications. Deliver five electroded crystals of suitable geometry for measuring the material's dielectric and piezoelectric properties.

PHASE II: Refine the Curie temperature, dielectric and electromechanical properties of the doped lead magnesium niobate-lead titanate (PMN-PT) electrostrictive single crystals to match the targeted properties designated by transducer designers. Scale up the process for manufacturing PMN-PT and maintain targeted properties. The scale up should increase the capabilities of the operation in at least two areas: 1) the quantity of crystals which can be produced in a given time and @) the size of the crystals which can be produced. Produce and deliver a sufficient umber and size of electroded crystals to glue up and test as a stack.

PHASE III: Qualify doped lead magnesium niobate-lead titanate (PMN-PT) single crystals as a transducer material. Partner with transducer manufacturers to produce transducers using single crystal PMN as the active material. Produce doped PMN single crystals for use in transducers.

COMMERCIAL POTENTIAL: A wide array of industries will benefit from advances in the area of electrostrictive ceramics. The application areas for PMN include optical (deformable mirrors, bistable optical devices and swing CCD image sensors), mechanical (ultra-precision guide mechanisms, VTR heads, oil pressure servo-valves and ink jets) energy transfer (ultrasonic surgical knife, piezoelectric pump), and optical/mechanical (ultrasonic motors and robotics). This list is by no means complete.

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- 2) S.L. Swartz and T.R. Shrout, "Fabrication of Perovskite Lead Magnesium Niobate," Mat. Res. Bull., Vol 17, pp. 1245-1250, 1982.
- 3) S. M. Pilgrim, M. Massuda and A. E. Sutherland, "Electromechanical Determination of the High-Field Phase Transition of Pb(Mg1/3Nb2/3)O3-PbTiO3-(Ba,Sr)TiO3 Relaxor Ferroelectrics," J. Am. Ceram. Soc., Vol. 75, 1970-74 (1992).
- 4) K. Uchino, "Electrostrictive Actuators: Materials and Applications," Ceramic Bulletin, Vol. 65, No. 4 (1986).
- 5) U. S. Patent Number 5,023,032, 6/11/91, Inventors: A.E. Bailey, S.R. Winzer, A.E. Sutherland, A.P. Ritter, Assignee: Martin Marietta, "Electrostrictive Ceramic Material Including a Process for the Preparation Thereof and Applications Therefor"

# N97-094 TITLE: SC 21 Ship Information Systems Virtual Prototyping

OBJECTIVE: Develop a modeling and simulation (M&S) system to characterize, model and optimize performance and reduce the technical risk of initial design of and future upgrades to the SC 21 ship information system (SIS) architecture.

DESCRIPTION: M&S capabilities are required to significantly reduce lifecycle costs of the SC 21 program. This effort would adapt M&S tools and techniques to help ensure the affordability, capability, scalability, upgradeability, and flexibility of the SC 21À\_As SIS architecture. Additionally, it would facilitate the development of a real©time distributive emulation environment to support SC 21 test and evaluation requirements.

PHASE I: Determine feasibility and optimum approach for an M&S system designthat supports virtual prototyping of SC 21À\_As SIS architecture optionsincluding real time distributed emulation using remotely located Navyfacilities, models and simulations.

PHASE II: Develop and demonstrate ability of SIS architecture virtual prototyping system to accurately simulate SIS designs.

PHASE III: Utilize virtual prototyping system to identify required SISarchitecture design specifications in support of SC 21 Phase I contractaward.

COMMERCIAL POTENTIAL: Similar techniques have been applied in both theaircraft and micro chip manufacturing industries. An expansion of these techniques will assist DARPA implementation of their Nationwide Heterogenous Distributed Computing Vision.

REFERENCES: Briefings to SC 21 Program Manager on modeling and simulation to support SIS architecture design.

# N97-095 TITLE: Software for Automated Electronic Classroom Implementation

OBJECTIVE: Enable managers to make decisions and commitments regarding the most appropriate implementation strategies related to software for automated electronic classrooms. Access information regarding current capabilities of software products able to control the operation of all envisioned functions of media to be installed in military automated electronic classrooms and other forms of learning laboratories.

DESCRIPTION: A variety of installations with diverse configurations have been installed or are planned in a number of DOD training facilities which may be loosely described as automated electronic classrooms. To provide multimedia presentation software tools that offer the instructor the capability to create, present, modify, and update instructional material in a PC based classroom, controlling and integrating software is required. No single reliable multi-platform software suite has been developed which is capable of driving the equipment necessary to implement fully what has been installed or is proposed for military automated electronic classrooms. Without the required technical standards for software in operating system open architecture protocols, specific CPU and bus architectures, multimedia co-processors, multimedia interfaces and file formats etc., there is significant danger that what will evolve is a hybrid of incompatible new and obsolete technology requiring too much maintenance.

PHASE I: Develop a Data Base of Training technology resources, including related software, multimedia and networking technologies architectures, systems, applications standards and specifications including functional descriptions, industry standardization issues and compliance with DOD procurement directives. Perform surveys, and conduct liaison and evaluation of available commercial and Government training resources, and provide the results in a common database file format, such as Access. This should display for decision makers, capabilities, license arrangements, costs and the like.

PHASE II: Develop an integration strategy which will give DOD a robust future proof enterprise system that will fully integrate and implement a coherent technology based on computer-based training.

PHASE III: Based on the findings of Phase II, design a system to provide fully capable, instructionally sound classroom installations.

COMMERCIAL POTENTIAL: Such a comprehensive system has applications in both industrial training settings and the academic environment.

#### NAVAL MEDICAL RESEARCH and DEVELOPMENT COMMAND

N97-096 TITLE: Process Improvement/Enhancement System For Critical Care Medicine

OBJECTIVE: Establish a system using optimal techniques for the determination of root cause events producing iatrogenic illness.

DESCRIPTION: Iatrogenic complications during the course of patient treatment are extremely costly both monetarily and in terms of patient well-being. Because the complexity of modern health care requires the application of emerging technologies and coordination among highly skilled professionals, isolation of iatrogenic causal factors is extremely difficult. Process enhancement and improvement programs must be modified to effectively minimize costs and maximize efficiency and military medical readiness.

PHASE I: Human-systems methodologies and technologies will be applied to the critical care environment to develop a system that aids in the determination of root cause events producing iatrogenic illnesses. The system should be employable at every echelon of DON medical care, summarize information and unburden care providers from report generation, and demonstrate significant improvements in terms of information quantity and quality over existing

process improvement and enhancement procedures. Plan for collection of baseline data and changes in illness rate resulting from interventions should be proposed.

PHASE II: Evaluate the proposed system for sensitivity and validity. Baseline data collection and system implementation will be conducted at a Navy medical facility. The impact on medical costs and readiness are to be determined during this phase. Resulting system databases would require configuration for use in developing process improvement strategies, procedural remedies, and training materials.

PHASE III: Implementation and transition into medical information systems.

COMMERCIAL POTENTIAL: Iatrogenic complications are inherent in all health care delivery systems, as are requirements to improve existing quality assurance/process enhancement programs. Thus, the proposed system would have significant potential within civilian hospitals and clinics.

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- 1. Gardner-Bonneau, D. J. (1993). What is iatrogenics, and why don't ergonomists know? Ergonomics in Design, July, 18-20.
- 2. Leap, L. (1991). The nature of adverse events in hospitalized patients: results of the Harvard Medical Practice Study II. New England Journal of Medicine, 324(6), 377-384.

### OFFICE OF NAVAL RESEARCH

N97-097 TITLE: Sensors and Components for Underwater All-Optical Arrays

OBJECTIVE: Enable the development of affordable, high performance underwater surveillance arrays which use acoustic and non-acoustic sensors. These arrays are towed by surface ships and submarines or mounted on the ocean floor.

DESCRIPTION: All optical arrays are arrays of underwater sensors that do not have any electrical components in the wet end. They generally include the following components: a laser light source which powers the array; transducers which produce optical output in response to the influence of physical phenomena of interest; components for optically multiplexing the output signals of a number of sensors; a photodetector which converts the multiplexed optical signal into an electrical signal; and a method or demultiplexing, beamforming and signal processing the resultant electrical signal, Methods for optical demultiplexing, beamforming, signal processing, and fusing the output of different sensors are also under investigation. The focus of this SBIR topic is to stimulate bold new concepts for significantly improved sensors and components for optical arrays, with emphasis on affordability and improved performance, New sensing or multiplexing concepts which reduce the number of discrete optical components or the amount of hand labor involved in array assembly are also desired.

PHASE I: Develop a conceptual design of the proposed sensor or component. This design and supporting documentation should be sufficient to convince qualified engineers that the proposed concept is technically feasible.

PHASE II: Produce and demonstrate performance of an "eXploratory Development Model" (XDM) of the proposed sensor or component. Construct the XDM to demonstrate performance in the most cost effective manner. Demonstrate performance in such a way as to convince qualified engineers that the proposed sensor or component is capable of meeting requirements in an operational environment.

PHASE III: Team with the manufacturer of one of the Navy's underwater surveillance arrays to integrate the sensor or component into future generations of the array. Team with manufacturers of commercial communication, control, or surveillance networks to integrate the sensor or component into these products.

COMMERCIAL POTENTIAL: The commercial market for improved optical systems is large and is driven by the need for low cost, high bandwidth communication networks. Improved multiplexing and array assembly techniques may be applicable to the commercial fiber optic industry. Low cost optical sensors also have commercial applications in perimeter security, equipment monitoring, pipeline leak detection, oil exploration, and the emerging market for "smart" buildings.

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- 3. Dandridge, A., et al., "Acoustic performance of an all-optical deployable system (AODS) sub-array module (SAM)," NRL Memorandum Report NRL/MR/5670-96-7835, March 27, 1996

# N97-098 TITLE: Biologically Inspired Processor for Contact Data Association

OBJECTIVE: Development of commercially available biologically inspired data processing methods, techniques, or algorithms, such as artificial neural networks, for the contact association function of the Navy's submarine combat control system.

DESCRIPTION: Future undersea warfare, in the littoral environment, will present much shorter engagement ranges, new threats, environmentally imposed uncertainties, and the higher likelihood of melee encounters. Such factors combine to make the task of target track estimation and evaluation much more important and difficult than for deep water. The Navy has adapted, on a science and technology level, a biologically based system as a tracking component of a contact management subsystem within the submarine combat control system. The component, Neurally Inspired Contact Estimation (NICE), enhances current capabilities for multi-source, real-time data assimilation, fusion, and correlation. The goal of this topic is to provide a natural and needed extension to NICE--the association of acoustic and non-acoustic data with individual contact tracks.

PHASE I: Demonstrate, using synthesized data and directly interfacing with NICE, the feasibility of a biologically based system for accomplishing contact data association for two or more contacts with constant motion.

PHASE II: Full algorithm development and validation with assessment of system performance against synthetic and data from at sea exercises. The latter includes intermittent and uncertain data and data on maneuvering contacts. Deliver software module(s) that can be added to the current prototyped NICE system.

PHASE III: Transition to production as part of the NICE component of the contact management system.

COMMERCIAL POTENTIAL: The techniques, methods, algorithms will have direct relevance to any application requiring real-time data association, assimilation, fusion, and correlation--for example, military and Federal Aviation Administration (FAA) tracking of aircraft, National Oceanic and Atmospheric Administration (NOAA) localization and tracking of fish schools, Department of Transportation (DOT) systems for localization, tracking, and directing traffic.

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- 2. "Neural Network Based Data Fusion System," by C. M. DeAngelis, Navy Case Number: 74703, Filed: 18 October 1994, Awarded: slated for July 1996, Patent Number: TBD.
- 3. "Neural Network Based Contact State Estimator," by C.M. DeAngelis and R.W. Green, Navy Case Number: 77289, Filed: 7 May 1996, Awarded: patent application evaluation in process.
- 4. "Neurally Inspired Multi-Source Acoustic Data Fusion," by C.M. DeAngelis, J.L. Harrison, K.J. Ross, and R.W. Green, U.S. Navy Journal of Underwater Acoustics, July 1995.

# N97-099 TITLE: Reflective Liquid Crystal Display Utilizing Conducting Polymer Substrate

OBJECTIVE: Develop and demonstrate the working of a prototype ultra high resolution cholesteric liquid crystal display on plastic substrates with conducting polymer as the conducting material.

DESCRIPTION: Liquid crystal displays often are insufficiently ruggard, have high power requirements due to back lighting, have restricted viewing angles, and are hard to read in bright ambient light. In this project these deficiencies

will be addressed with a program aimed at the development and demonstration of a prototype ultra high resolution cholesteric liquid crystal display on plastic substrates with conducting polymer as the conducting material. it is anticipated that the displays be at least 6" x 4", have 160 dpi resolution, multicolor capability, and 0.1 second page refresh rate. In addition, the displays will be portable, ruggard, light weight, sun light readable, and will consume low power.

PHASE I: Develop innovative methods to fabricate 6" x 4" cholesteric liquid crystal displays on conducting polymer with a resolution of 80 dpi. Design and develop driver and packaging electronics capable of page refresh rates of 0.1 seconds. Evaluate the electro optic properties of the display using this drive circuit.

PHASE II: Improve refresh rate to 0.1 second and enhance resolution to 160 dpi; demonstrate multicolor capability; reduce effort to engineering practice.

PHASE III: Scale up fabrication/processing to pre-production level; evaluate feasibility for manufacturing for commercial and military applications.

COMMERCIAL POTENTIAL: Applications of this technology would be found in hand held displays, electronic billboards, portable map/text/graphic readout displays, and games.